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# THE PURPLE SCALE

By H. J. QUAYLE

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# THE PURPLE SCALE.

**Lepidosaphes beckii** Newm.

By H. J. QUAYLE.

## EARLY HISTORY.

The purple scale, *Lepidosaphes beckii,* was first made known by Newman in an account appearing in the English publication "The Entomologist" in Februrary, 1869.[1] In August of the same year Packard[2] in this country gave a brief description of the same insect, calling it *Aspidiotus citricola.* Newman had given it the genus name *Coccus,* which has since been changed, while his species' name *beckii* still stands. From 1870 to 1876 a few articles appeared on this insect in France and Italy. Glover has the second notice of its occurrence in the United States in the United States Department of Agriculture Year Book for 1876. He stated that it was found on imported lemons in Jacksonville, Florida, in 1857.

The description of this insect given by Packard was made simply from unpublished figures and, of course, was inadequate. The first complete description was given by Comstock in his 1880 report, but he adopted the same specific name as that given by Packard.

*Introduction into California.*—The purple scale seems to have been introduced into California directly from Florida in 1888 or 1889. In the report of the California State Board of Horticulture for 1893 Alexander Craw states that "four years ago two carloads of orange trees were received in this State from Florida and planted in Los Angeles and San Diego counties without disinfection. The result is that the climate that has been preached us by importers of Florida stock as unfavorable to the development of this species of scale has proved to be the opposite, for on a visit to the above counties last summer I was shown trees completely covered with purple scale." The May number of the *Rural Californian* for 1889 was largely occupied with discussions of the probable damage which would result from the importation of Florida scales, among which the purple was the most important. Dr. Riley, writing in *Insect Life* in 1889, states that "we have received a number of letters from California asking our opinion on the necessity for quarantine, and have replied that while there seems reason to believe, and we are inclined to believe, from the evidence at hand, that the scales men-

[1]The Entom. IV, p. 217 (1869).
[2]Guide to the Study of Insects, p. 527 (1869).

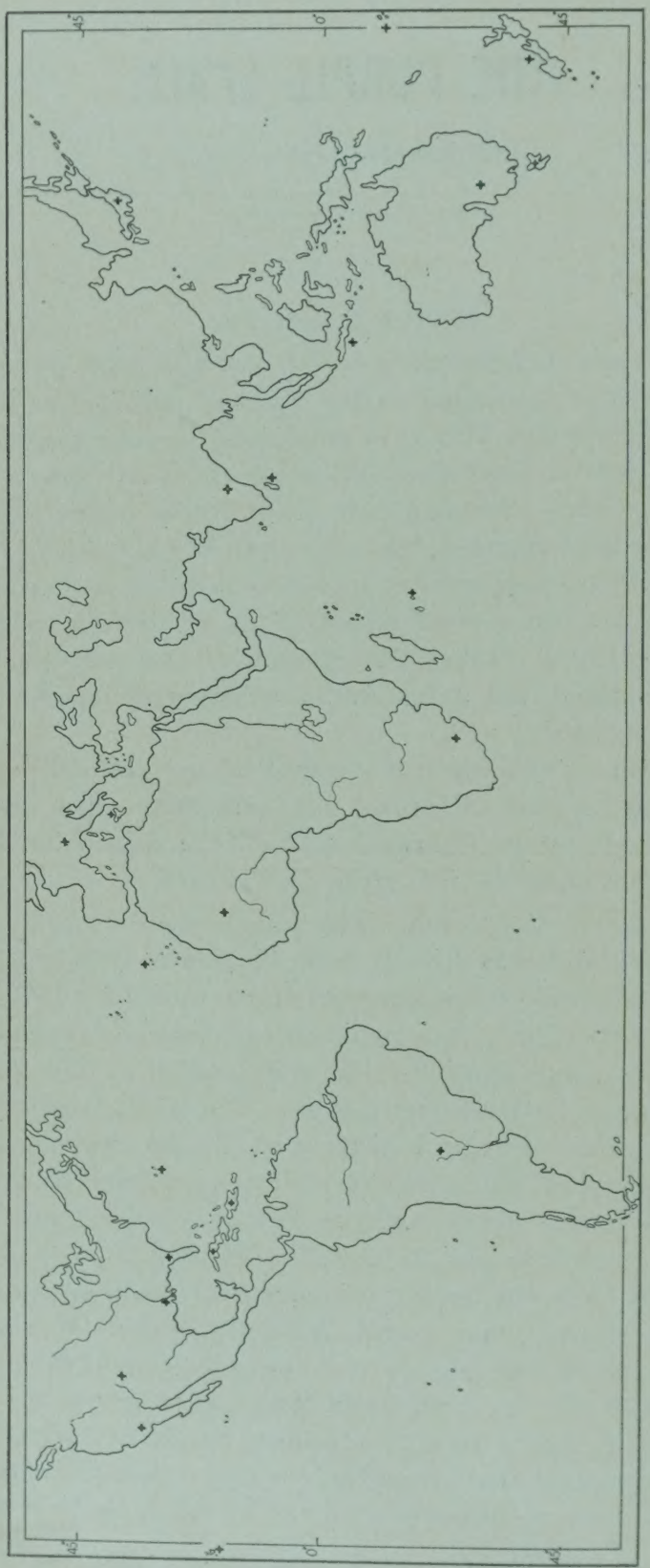

FIG. 1.—Map indicating distribution of purple scale over world.

tioned will not flourish in certain parts of southern California, like Riverside, where the heat and dryness are great, yet it will be unwise to depend too much on the limited experience of the past. We have, therefore, reiterated our convictions as to the necessity of using every precaution to prevent their introduction."

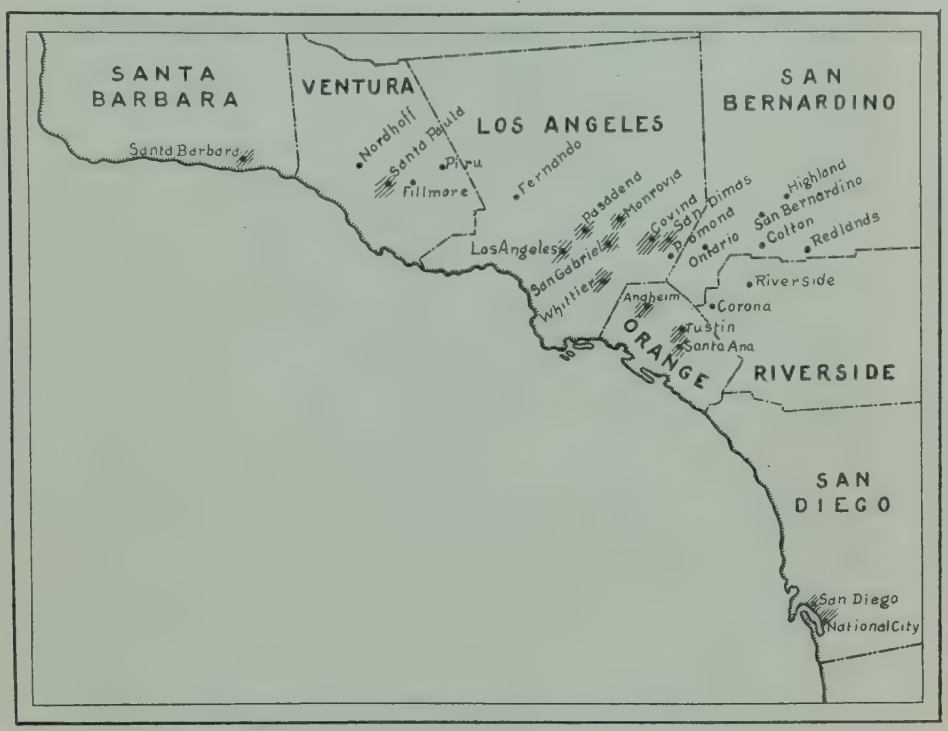


FIG. 2.—Map showing distribution of the purple scale over the southern California citrus belt.

## DISTRIBUTION.

*Over World.*—The purple scale is widely distributed over the world, as reference to the map will indicate. The localities as represented by the +s on the map are as follows: Europe, Maderia, West Africa, Mauritius, Ceylon, Japan, Australia, Tasmania, New Zealand, Fiji, Hawaiian Islands, Bermuda, Java, West Indies, Paraguay, Florida, Louisiana, Colorado, and California.

The Paraguay locality given above is based upon material received in July, 1911. Mr. C. F. Mead collected some orange leaves that had a sickly appearance from Pirapo, Paraguay, and sent them to Professor Coit of this station. The leaves proved to be infested with typical purple scale. Hitherto there have been no published records, to our knowledge, of this scale occurring in that locality or even on the continent of South America.

*In California.*—At the present time the purple scale occurs in the following counties in California: San Diego, Los Angeles, Orange,

Ventura, and Santa Barbara. It does not occur, thus far at least, in the citrus sections of the San Joaquin and Sacramento valleys. Neither does it occur in Riverside or San Bernardino counties. From its distribution in the above coast counties it would appear that it thrives best in a cooler and moister climate, and in this respect it is similar to the

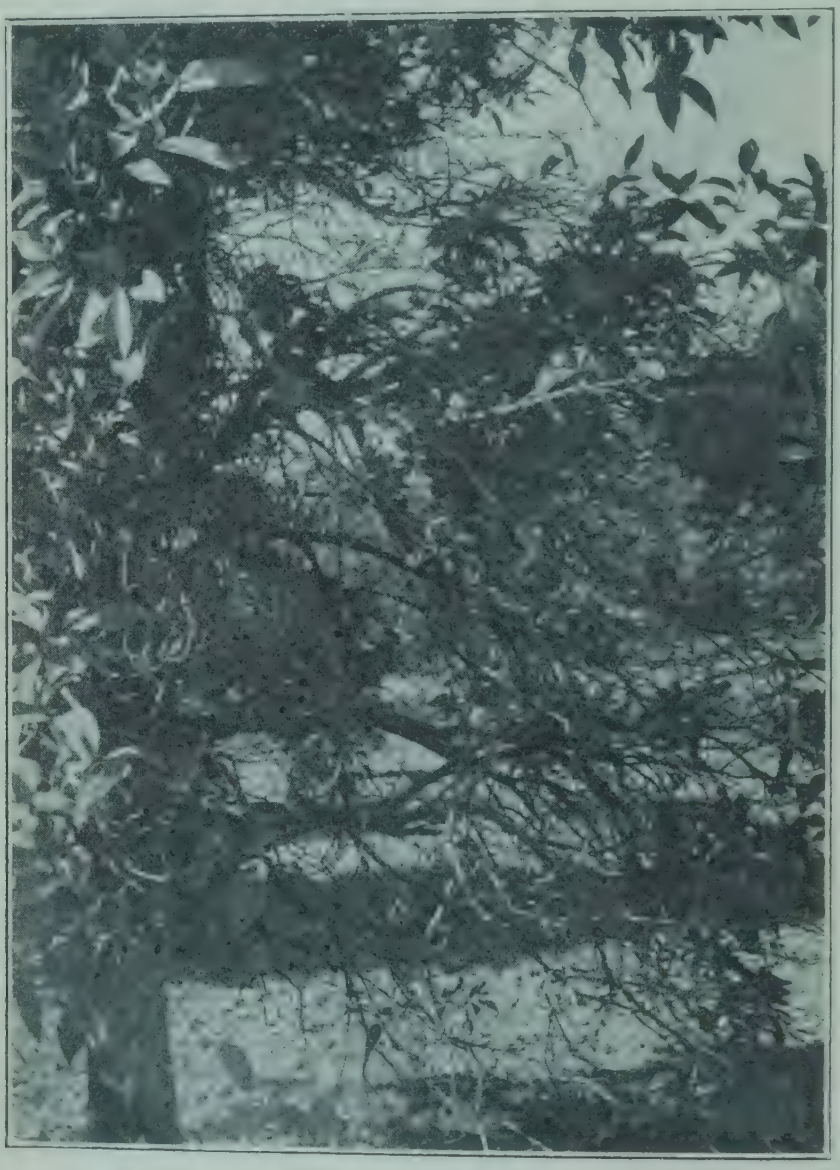

FIG. 3.—Half of orange tree defoliated by purple scale.

black scale. But the fact that it does not occur in the warmer and drier locations may be due to the very rigid quarantine that has prevailed against this scale in those sections. Its present eastern limit, or distance from the coast, is in the eastern part of Los Angeles County, but here the climatic conditions approach that of the still more interior sections

of Redlands and Riverside, so that there are no well defined climatic zones, and therefore it is not improbable that the purple scale would establish itself in those sections.

## ECONOMIC IMPORTANCE.

Considering the scales of the whole of the southern California citrus belt, the purple is probably entitled to rank as the third most important. Its distribution is not so general as that of either the black, red or yellow, but where it does occur it is the most serious of them all, because it yields less readily to treatment. Where this scale occurs among others, fumigation work is directed primarily against the purple, and usually successful treatment against it readily controls the red or black scales.

The purple scale infests leaf, branch and fruit, often becoming completely incrusted upon these, but it is usually only a portion of the tree that becomes thus infested. The lower side or interior of the tree is where the insect thrives best, and here it is that the injury is most evident. We have never seen the greater part of a citrus tree actually killed by this scale, but a goodly portion of one side or the lower and interior branches are very frequently thus killed. The scale causes a marked yellowing of the leaves and there is consequently a heavy dropping so that many of the branches will be completely denuded.

The injury is due directly to the feeding, as is the case with the red scale, since no honeydew is excreted. The scales on the ripening fruit often have a tendency to delay the coloring, and a marked green spot will be seen about the scale while the rest of the surface is yellow. On account of their firm attachment to the fruit they are with great difficulty removed therefrom, so that the ordinary brushing or washing of the packing-house has little effect upon them.

The economic status of this scale is due largely to its resistance to such treatments as fumigation or spraying. It is not a particularly prolific insect for the maximum number of eggs will not exceed eighty, and there are not more than three, or at most four, generations a year. It is in the egg stage that it is most resistant to fumigation. This must be largely on account of the very complete protection afforded the eggs by the secretion of the ventral scale, which together with the dorsal scale completely envelops them. The only opening is at the posterior tip where the young upon hatching emerge. It has frequently been noticed that in cases of incomplete fumigation a few eggs at the extreme tip will be killed by the gas while the more interior and better protected ones will remain unharmed.

FIG. 4.—Orange leaf infested with purple scale. x2.

## FOOD PLANTS.

*Lepidosaphes beckii* is essentially a citrus fruit scale, and while it may occur on several other plants, it is restricted as a pest in California entirely to the different varieties of citrus. Fortunately, it does not

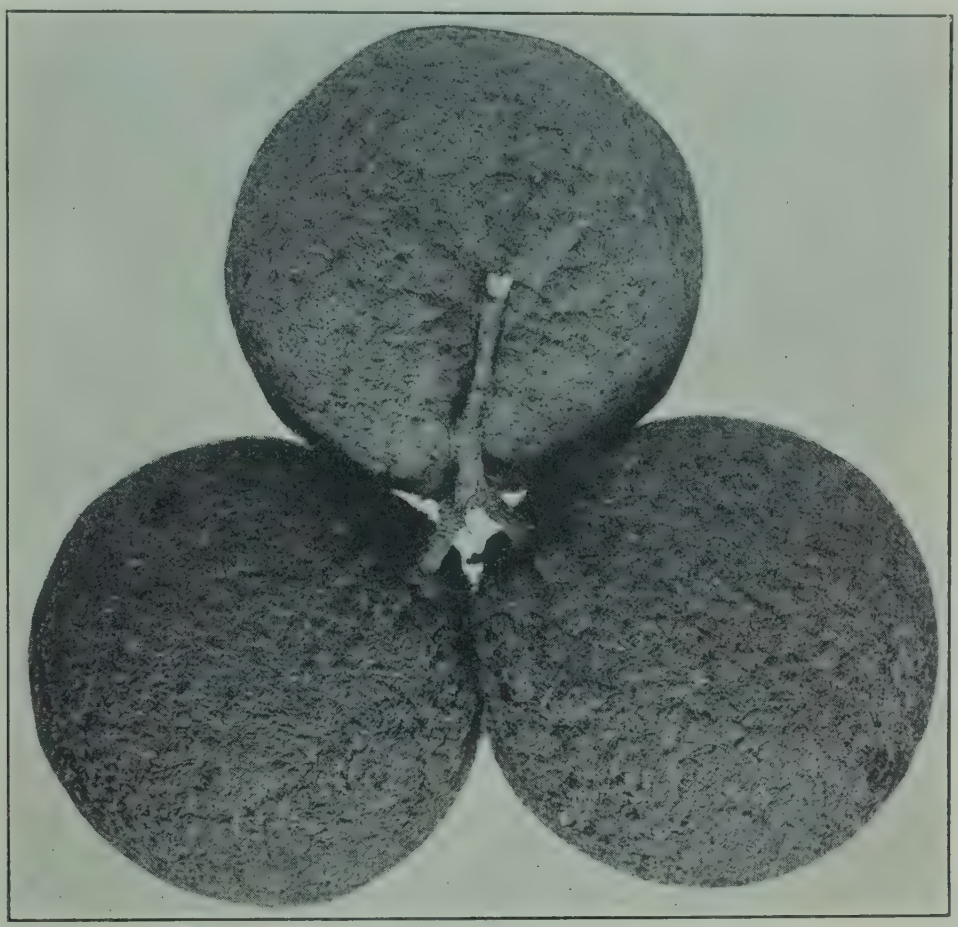

Fig. 5.—A cluster of oranges badly infested with purple scale.

attack, or at most but very rarely, any of the common trees or shrubs growing in the vicinity of citrus trees, so that the problem of treatment and control is limited to the commercial grove.

The complete list of food plants from which *Lepidosaphes beckii* has been recorded is as follows: Orange, lemon, citron, grape fruit, fig, olive, croton, oak, *Elaeagnus, Banksia integrifolia, Taxus cuspidata. Cercidiphyllum japonicum, Pomaderris apetala.*

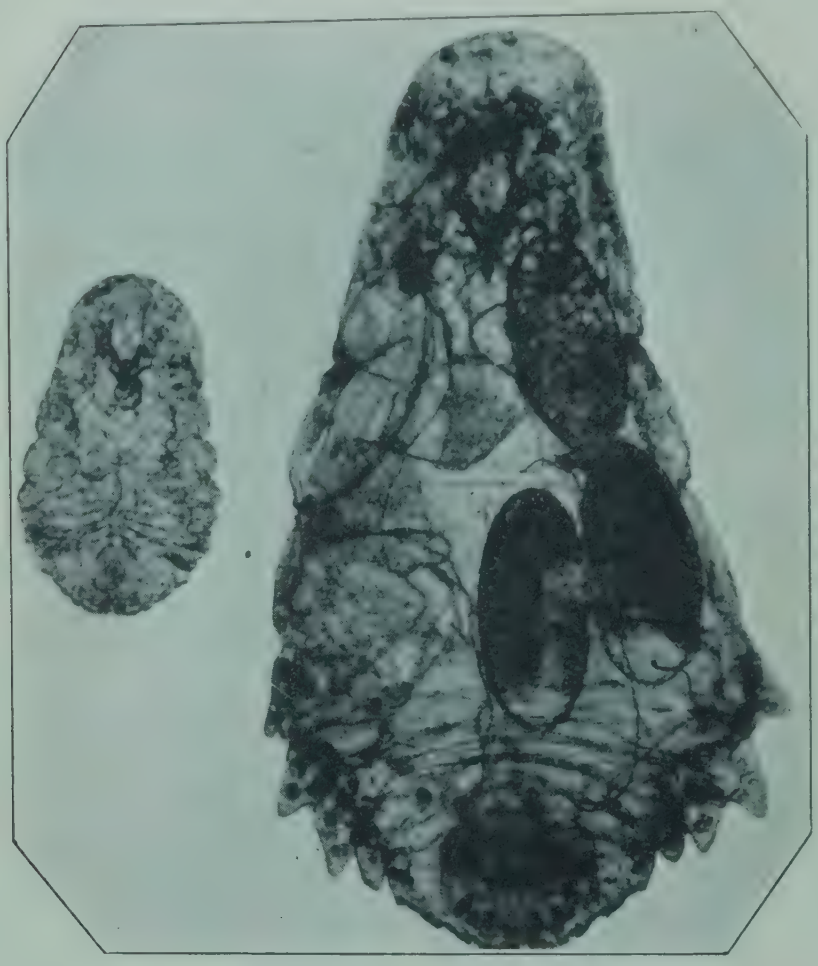

FIG. 6.—Purple scale after first molt, and mature female. x90.

## DESCRIPTION OF THE STAGES.

*The egg* is oval in shape measuring .25 mm. long and .15 mm. broad. The color is pearly white with the surface very minutely granulate.

FIG. 7.—Active larva of purple scale.

*The active larva* is a flat, oval-shaped creature, white in color with the posterior tip brown. The total length is .78 mm. and the greatest width is .64 mm. The antennæ are six jointed, the first joint broadest, the last longest and distinctly annulate. There are two small lobes widely separated at posterior end, and near each of these on the inner side is a spine which extends beyond the tip of the lobes. There are two other similar spines beyond the lobes.

*The second stage male* length .8 mm., width .25 mm.; general color purple. In the earlier part of this stage the purple pigment is confined largely to the anterior lateral margins. The rest

of the insect, excepting the posterior tip which is brown, is white in color. There are no distinct eyes at this time, but later the purple granules coalesce into definite areas forming the two pairs of eyes which are conspicuous in the latter part of the stage. The dorsal and ventral eyes are connected by a narrow neck so that they are continuous. These

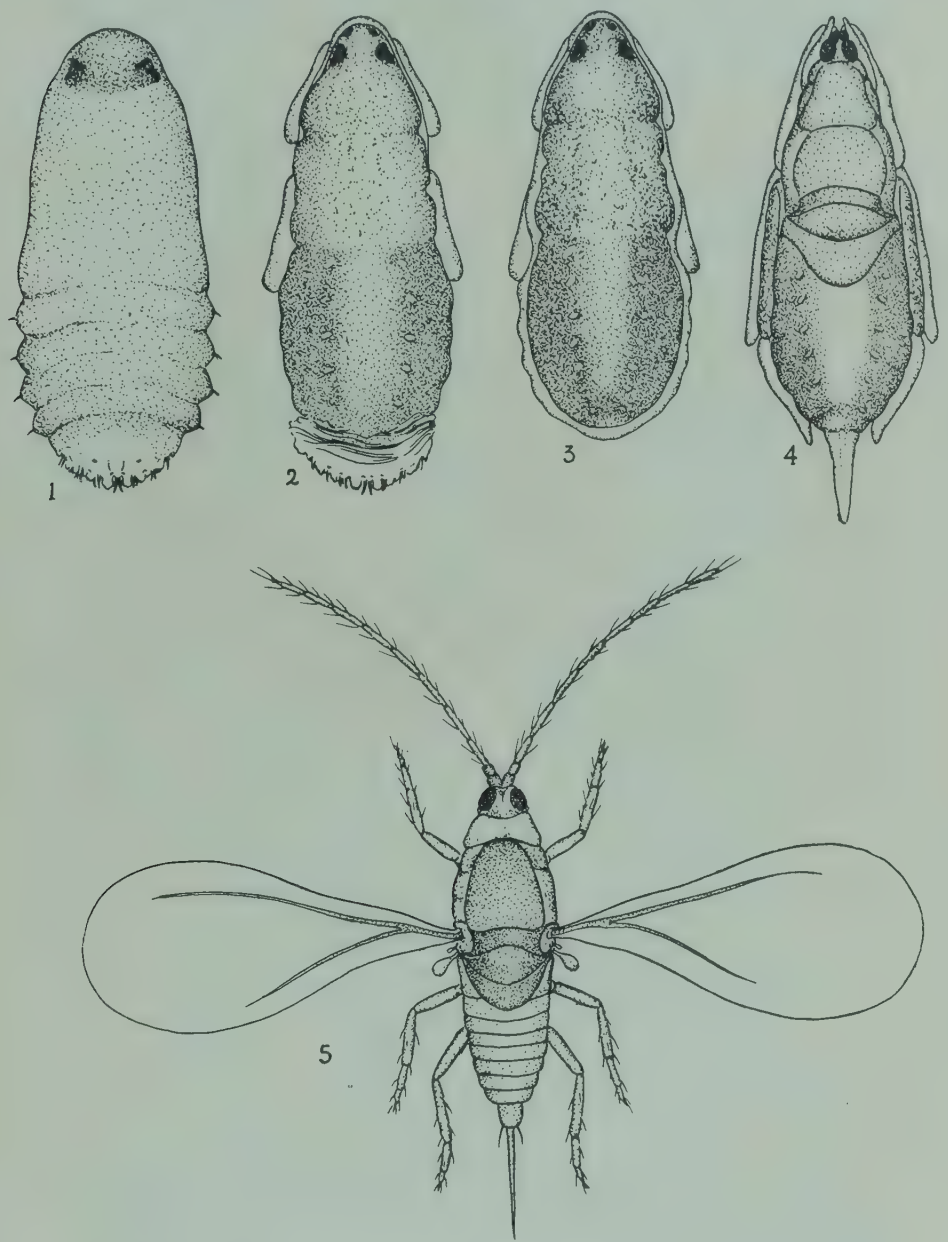


FIG. 8.—Stages of the purple scale male. 1. Second stage. 2. Propupa with exuvium of second stage still adhering to tip of body. 3. Propupa. 4. Pupa. 5. Adult male. x40.

are very dark purple. The median lobes are large and broad at base with the margin serrate. The second pair of lobes which are not conspicuous are strongly notched in middle. Two long tapering plates occur between the median lobes and also two similar in size and shape

between the first and second, and second and third lobes. Two other similar plates or spines are found beyond the third pair.

*The propupa* is purple in general color and measures .8 mm. long and .25 mm. wide. The sheaths enclosing the antennæ legs and wings may be distinguished, but they are closely associated with the body and are not conspicuous. The pygidial characters have disappeared and the posterior end is now truncate with no evidence of the style. The ventral eyes are large, very dark purple in color, and lie close together. The dorsal eyes are smaller and farther apart.

*The pupa,* length exclusive of style .1 mm., width .28 mm. at widest part, which is near posterior end. Color purple. Sheaths of the appendages conspicuous and more or less free from the body. Eyes purple, the ventral pair closer together than the dorsal.

*Adult male,* length exclusive of style .58 mm., style .21 mm., wing expanse 1.6 mm., antennæ 10 jointed; comparative lengths 5, 5, 19, 23, 22, 20, 20, 18, 20, 15. General color, yellowish with purple pigment scattered about with most at anterior end. This pigment also extends into the joints of the antennæ excepting the last two joints. The thorax is light brown with a darker band extending between the wings.

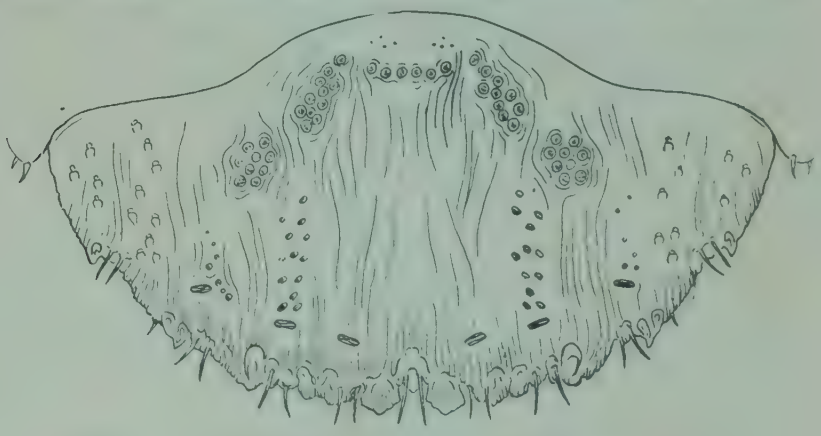

FIG. 9.—Pygidium of adult female purple scale. x160.

*The adult female* will average 1.2 mm. in length and .7 mm. in width. On the lateral margin, beginning at the anterior end, are from three to four broadly rounded extensions, and following these from three to four pointed protuberances, all excepting the most anterior having short, blunt spines at tip. There are always three pairs of lobes visible and often a fourth. The median lobes are broad and bluntly pointed, with more or less indication of serrations. The second pair is broad and deeply notched, the third short and broad with serrated edge.

FIG. 10.—Purple scale. 1. Development of scale covering. x12. 2. The beginning of the formation of the scale covering. x120. 3. Male and female scales, showing comparative size and shape. x27. 4. Dorsal and ventral view. 5. Two stages of larva of Aspidiotiphagus citrinus within purple scale. 6. Pupæ of same within [illegible]. 7. Exit holes of A. citrinus. [illegible]

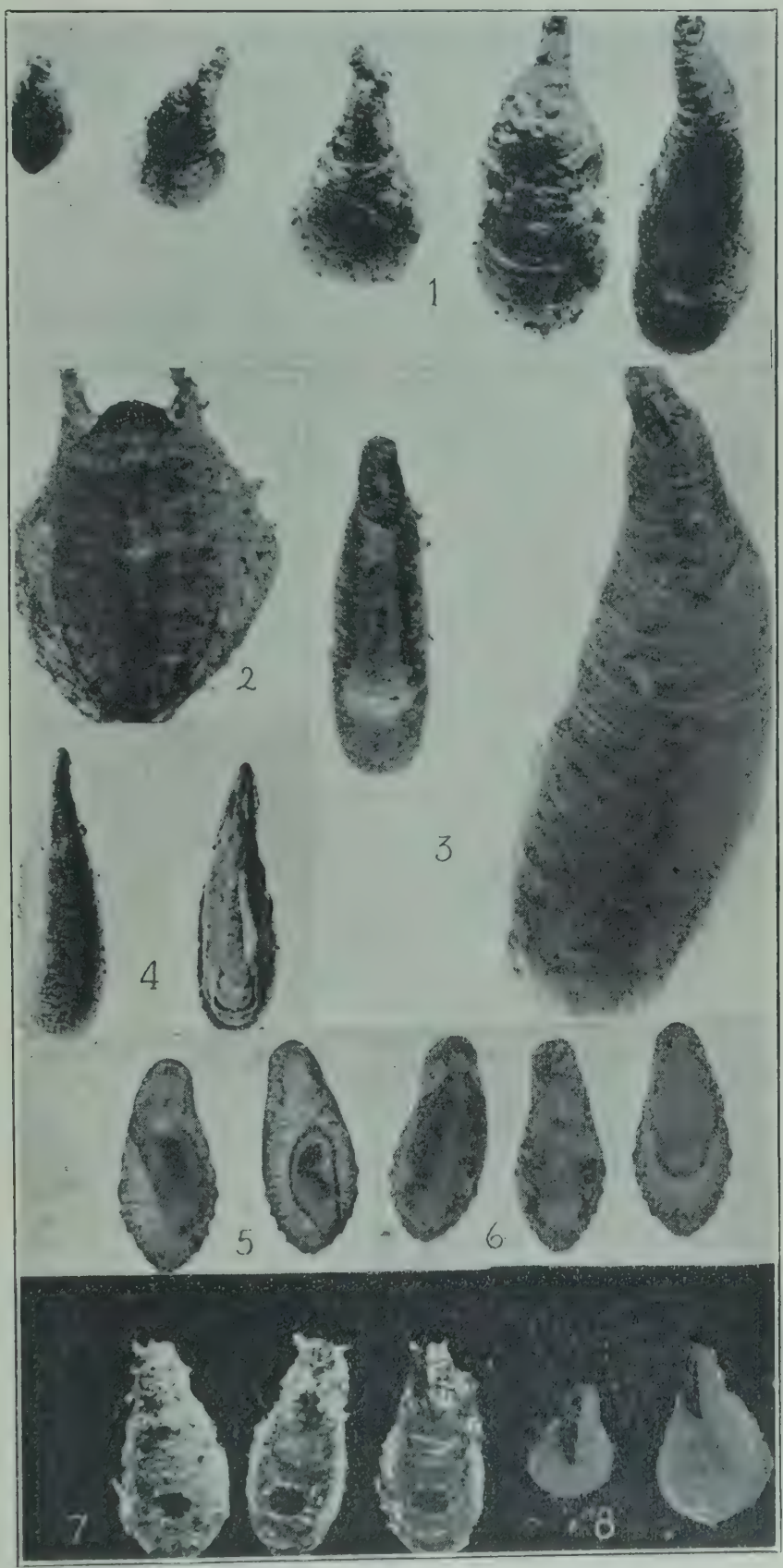


FIG. 16.—See opposite page for legend.

There are two spine-like plates between the median pair between the first and second, and second and third. There are also two between the third and what might be called the fourth pair, which show distinctly in some of the specimens. Another pair of these spine-like plates is found at the extreme edge of the segment. The spines that are conspicuous are two on each of the median lobes and one at the incision of the second.

## LIFE HISTORY AND HABITS.

*The Egg.*—The eggs of the purple scale are protected, not only on the upper side of the scale covering, but on the under side, by a lighter and more cottony secretion, so that they are practically surrounded on all sides excepting at the posterior end. They are arranged in regular rows and standing partly on end. The number will vary from forty to eighty. These are deposited over a period of three or four weeks. The time of hatching will vary from fifteen days in summer to three weeks or longer in the winter months. Those nearest the tip are the oldest and are the first to hatch. As the quota of eggs are deposited, the insect diminishes in size and contracts toward the anterior end of the scale, filling the space thus left with eggs.

### THE ACTIVE LARVA.

The active larva usually wanders about over the plant for a short time before settling. This period will vary from a few hours to two or three days, the majority becoming fixed within one day after emerging from the parent scale. The scales upon hatching may not make their way from beneath the scale immediately, especially if the weather is cool. But not many, generally not more than two or three, will be found hatched and not yet emerged.

*Locomotion.*—The rate at which the young larva will crawl over smooth paper varies considerably, according to the temperature. With a temperature of 64° F., the maximum distance traveled during a two-hour period was 27½ inches, while a distance of 111 inches was covered when the temperature was 89°.

LOCOMOTION OF YOUNG PURPLE SCALE.

| Number examined. | Date. | Time. | Temperature. | Distance. | Average distance. |
|---|---|---|---|---|---|
| 1 | November 18, 1910 | 9:20-12:20 p. m. | 64° | 9 inches | |
| 1 | November 18, 1910 | 9:20-12:20 p. m. | 64° | 21 inches | |
| 1 | November 18, 1910 | 9:20-12:20 p. m. | 64° | 27.50 inches | 19 inches |
| 2 | November 2, 1910 | 9:30-11:30 p. m. | 68° | 28 inches | |
| 2 | November 2, 1910 | 9:30-11:30 p. m. | 68° | 37.75 inches | 33 inches |
| 3 | July 21, 1910 | 1:20- 3:20 p. m. | 89° | 111 inches | 111 inches |

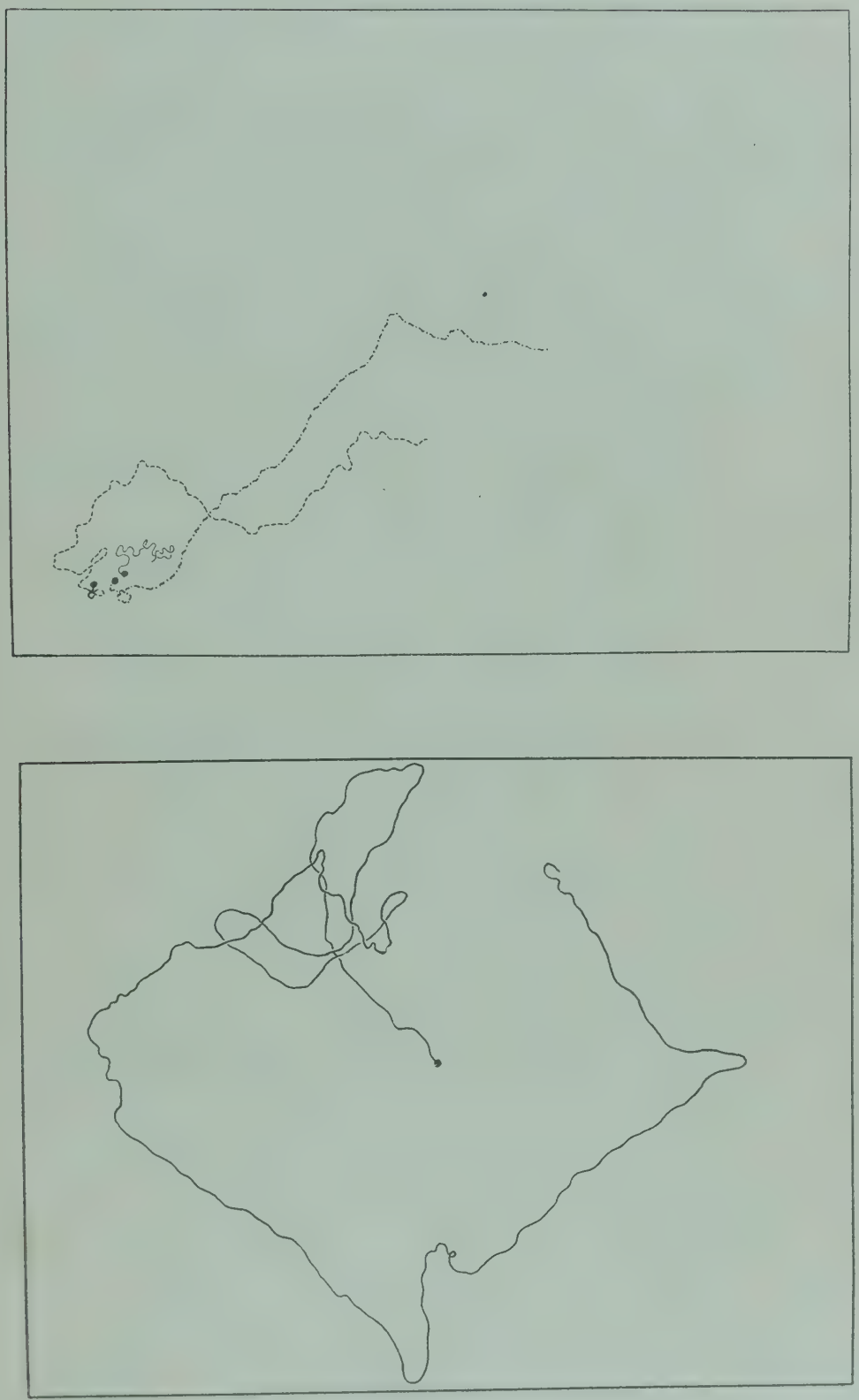

FIG. 11.—Actual tracings of the movement of young purple scales for a two-hour period; reduced 7 times. Above, the temperature was 64° and the average distance covered was 19 inches. Below, the temperature was 89° and the distance covered was 111 inches.

The rate and distance of travel noted above was on smooth paper. The conditions were thus more favorable than will ever be likely to obtain in nature. Counting the maximum length of life as an active larva when deprived of food at four days, the highest possible record under the most favorable conditions would be a total of 444 feet. But obstacles to travel, such as a pulverized soil, make a very different story.

With a temperature of 86° at 9 a. m., twenty-five active young were placed unharmed in the center of an area of sand, having a five-inch radius. None reached the edge during the same day or the day following. Another similar experiment resulted negatively. A third, similar to the others, was started, and out of twenty-five scales liberated, one reached the margin in 5¾ hours. This was the only one that succeeded in crossing a five-inch strip of sand.

The following records were made on a three-inch radius of sand:

| Number liberated. | Temperature. | Time. | Results. |
|---|---|---|---|
| 20 | 63°F | 1:30 p. m. | None reached margin |
| 20 | 82°F | 9:45 a. m. | 2 out at 12:30 |
| 10 | 65°F | 9:30 a. m. | 2 out at 1 p. m. |

Other tests were made with orchard soil, but there seemed to be little difference over that of sand. It will thus be seen that the young purple scales are able to make but little progress over soil that is well cultivated. Only an exceedingly small percentage of those liberated crossed but three or five inches of such soil. If the soil is compacted as after heavy rains or in irrigation furrows considerable progress may be made, but even here the factor of their own powers of locomotion in their distribution is very small.

*Settling.*—Out of 240 scales liberated in leaf cages at different times from March to September, 122 or about 50 per cent became established. This should represent a fair average, or, if anything, an under estimate of the percentage, since the young were liberated on suitable leaves and protected from all outside agencies. There seems no doubt that conditions as they ordinarily obtain in nature would decrease the above percentage considerably. It may, therefore, be counted that at least 50 per cent of the scales fail to become established even under the most favorable conditions.

The young purple scale may settle either on the branch, leaf, or fruit. The branches or leaves are the first to become infested, but if they are abundant on these, the fruit in the vicinity will become badly infested also. Where the numbers are not large there is a tendency for the young scales to settle along the midrib or large veins of the leaf. This tendency was usually strongly shown in our breeding cages. They do

not migrate far from the parent as a rule. It is most usual to find this scale limited to but a portion of the tree, and while this portion may be so severely infested as to be killed, the rest of the tree may be in a healthy condition and comparatively free from the scale. The infested portion is nearly always on the lower side of the tree and later extends upward covering the greater part of one side of the tree. This side is not necessarily away from the sun for it has been noted on the east, south and west sides of the trees.

*Formation of the Scale.*—Upon settling, the young larva of the purple scale very soon secretes a couple of rather coarse cottony threads from the anterior end of its body, apparently from just under the margin of the anterior end. These are long entangling threads that extend entirely over and around the insect. The function of these is undoubtedly a provision for protection while the more compact covering is being secreted. At any rate these entangling threads answer this purpose, for it has been many times observed that a young *Coccinelid* larva upon striking them will immediately back away or turn in another direction without molesting the insect thus protected. These entangling threads remain until the insect is about half grown, and, where the young scales are numerous, they form a fuzzy coating over the infested surface. Some practical fumigators use this as a criterion that the insect is in the best stage for treatment; and this is correct, for such threads are lost as they approach maturity.

After these two long protecting threads are formed the insect begins the secretion of the permanent scale. These threads are very much finer than the first ones and cover the insect more compactly. The covering for a day or two is of course thin enough to make out very readily the insect beneath. This covering is started at the posterior end, and, after about one day, only the anterior one fourth of the insect is free. The long, entangling threads are still present and these remain for a considerable time. Later, however, after the scales are about one half grown they are lost. After the covering has reached the anterior end and the insect is completely covered, it still extends the covering in two horn-like projections as shown in Figs. 10-12. If these are carefully lifted the antennæ will be found beneath so that they serve as a protection to the antennæ for a time. As the insect grows older, the scale becomes more compacted. When the first molt occurs, the entire skin is incorporated in the dorsal scale. The insect works its way out beneath, leaving the covering which has been secreted, and the cast skin, above it. Very soon, however, the scale is extended posteriorly so that the cast skin becomes an oval, dark brown plate at the anterior tip of the scale. The second cast skin, which is very much larger than the first, is also incorporated into the dorsal scale covering. The secretion is continued and the scale extended beyond the second exuvium until the

part beyond becomes the length of the rest of the covering. As the female becomes mature and egg laying begins, a considerable secretion is formed on the under side. This is secreted from the sides of the insect, the two films meeting down the central line. A narrow strip of this ventral scale is formed on either side of the scale beneath during the earlier stages, particularly at the anterior end, and this gradually widens and extends more posteriorly as the insect becomes mature. But no part of the cast skins are found in this ventral scale which is entirely the secretion of the insect.

In the case of the male only the first cast skin is incorporated into the scale covering. This is exactly similar to that of the female, since there is no difference in the sexes until after the first molt. But all succeeding cast skins of the male are pushed back and from beneath the scale covering. The narrow, elongate covering, typical of the male insect, is formed entirely during the second stage of the insect.

*The Process of Molting.*—In the case of the purple scale the molting process is very different from that of *Chrysomphalus aurantii* and also different from that of the unarmored scales as represented by *Saissetia oleæ*. In the case of the red scale, the rent in the old skin occurs along the margin of the body, so that the dorsal half becomes incorporated in the dorsal scale and the ventral half of the ventral scale. In *Saissetia oleæ, Coccus hesperidum,* and others of the unarmored group, the skin is split at the anterior end and pushed backward and entirely free from the insect.

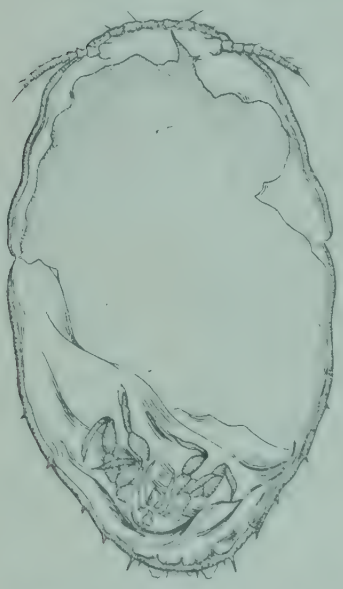

FIG. 12.—First cast skin of purple scale; ventral view, showing how skin is split and ventral portion with legs and mouth parts pushed back.

The rent in the skin of the purple scale occurs on the ventral side in a more or less irregular line a short distance from the margin. At the anterior end this is between the rostrum and the antennæ, on the sides, between the legs and the body margin; and at the posterior end, just anterior to the pygidium. The insect first emerges, presumably at the anterior end (the process can not actually be observed) and later pulls the posterior end forward and downward, leaving the old skin directly above it. From the appearance of the cast skin the insect could very readily, simply by a contraction of the body, free itself from the narrow projecting portion of the ventral scale at the anterior end. In the case of the posterior end, the rent does not occur so near the margin, hence the projecting scale is somewhat broader than that at the anterior end. But once the anterior end of the insect was free, it would be easy to liberate itself from this posterior pocket. That

the anterior end is first freed from the old scale is further shown by the fact that the old ventral skin is pushed backward, which would not be possible in any other case.

The exuvium, therefore, is entirely in the upper or dorsal part of the scale covering. After clearing in potash it will be seen that the antennæ are intact at the anterior end, the rent having occurred posterior to them, so that their position has not been changed in the molting process. At the posterior end all the characters of the pygidium can be made out as clearly as in the perfect insect, for these, likewise, have not been disturbed. As in the opposite end the insect has simply pulled itself from within, leaving all the characters undisturbed. The ventral portion of the molted skin, instead of being simply laid down beneath the insect, is pushed posteriorly as far as the pygidium, or to the edge of the rent at the posterior end. Here the legs and rostrum may be made out, the whole being more or less doubled up from the process of pushing backward underneath the insect.

*Development.*—The first molt of the purple scale occurs about twenty-six days after birth. Up to this period there is no difference between the sexes, but the difference becomes sharply marked immediately after this stage. In the case of the female, the period between the first and second molts is about the same as that from birth to the first molt. The second molt brings the female to maturity, at least so far as the molting is concerned.

Ten or twelve days after the first molt, the male undergoes a second molt, bringing it to the propupal stage. This stage is distinguished from the true pupa chiefly by the less fully developed appendages, as shown by their enclosing sheaths. After eight or ten days in this stage, it changes to the true pupal condition, and a similar period is passed in this stage before emerging as an adult. The male, therefore, issues as an adult about sixty days from birth. The period will be from ten to twelve days less during the warmest part of the season, and extended as much as twenty or twenty-five days in winter.

The female will begin depositing eggs about seventy-five days from birth, or fifteen days after fertilization by the male. Egg laying will continue for three or four weeks. The eggs hatch and young will emerge from the scale on an average of three months from birth; this again varying from ten or twelve days less in midsummer to a month or more in winter. After the female has deposited her quota of eggs, numbering from thirty to eighty, she dies, making the complete life cycle from four months in summer to from five to six months in winter.

LEPIDOSAPHES BECKII. DEVELOPMENT.

| Number examined. | Date. | Number liberated. | Number settled. | First molt. | Second molt, female. | Second molt, male. | Propupa. | Pupa. | Male emerged. | Male dead. | Eggs. | Young appeared. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 103 | 3-19-09 | 10 | 3 | | | | | | 6-10 | | | |
| 125 | 3-30-09 | 12 | 3 | | | | | | 6-6 | 6-10 | | |
| 116 | 3-24-09 | | | | | | | | 6-10 | 6-15 | | |
| 152 | 5-19-09 | 17 | 5 | | | | 7-6 | | | | | |
| 153 | 5-20-09 | | | 6-18 | | | | | | | | |
| 154 | 5-20-09 | | | 6-18 | | 6-26 | 7-1 | 7-8 | 7-16 | | | 8-16 |
| 155 | 5-20-09 | | | | | | | | | | | |
| 162 | 5-22-09 | 52 | 28 | | | | | | 7-21 | 7-24 | 8-10 | 8-16 |
| 163 | 5-22-09 | 37 | 21 | | 7 | 6 | 6-14 | | | | 8-1 | 8-18 |
| 166 | 5-25-09 | 46 | 36 | | 7-10 | | | | | | | |
| 167 | 6-25-09 | | | | 7-6 | 6-30 | 7-6 | | | | | 8-18 |
| 199 | 6-28-09 | 6 | 1 | | | | | 8-6 | | | | |
| 206 | 7- 1-09 | | | | | | 8 1 | 8-9 | 8-18 | | 9-16 | |
| 205 | 7- 1-09 | | | | | | 8-1 | 8-9 | | | 9-20 | 9-26 |
| 250 | 7-19-09 | 15 | 5 | 8-11 | | | | | | | | |
| 305 | 8-20-09 | | | | | | | | 10-27 | 11-2 | | 11-30 |
| 308 | 8-21-09 | | | | | | | | | | | |
| 580 | 6-18-10 | | | 7-10 | 7-26 | | 7-17 | | 8-6 | | | 9-11 |
| 581 | 6-18-10 | | | | | | | 7-24 | 8-5 | | | 9-19 |
| 582 | 6-18-10 | 15 | 7 | | 7-25 | | | | 8-10 | 8-14 | | |
| 583 | 6-18-10 | 15 | 9 | | | | 7-17 | 7-24 | | | | 9-9 |
| 584 | 6-18-10 | 15 | 4 | | | | | | 8-7 | | | 9-11 |
| | 2-18-11 | | | 3-6 | 4-17 | | | | 5-6 | | | |
| | 6- 8-11 | | | 6-30 | 7-25 | 7-13 | 7-20 | | 7-30. | | | |
| Summary averages | | | | 26 days | 50 days | 36 days | 44 | 52 | 60 | 65 | 75 | 90 |

## SEASONAL HISTORY.

Since the time required for the life cycle, from young to young, during the summer months is about three months and in winter may be prolonged a month or more longer, the number of generations will not exceed four. In fact, during ordinary seasons there will be but three generations, with probably a partial fourth. From May to October, inclusive, they will go through their development in three months, or slightly less, so that there will be two full generations during this period. A third will get fairly well started before the colder wet weather of January and February. But the development of this generation will be prolonged by the lower temperature so that it may require four months for the cycle. This will bring it into March again, when at best the fourth generation will only be partially developed by the last of April. During May, and also in June, young scales began appearing in large numbers, which is the first definite spring hatch. It is altogether likely that in many cases these are the progeny of the third generation. During the remainder of the summer young scales will be found continuously in considerable numbers. Eggs will be found at any season of the year, but during the winter months the young will appear mostly during the warmer periods.

## PARASITE.

Practically nothing has been written about any parasites of the purple scale in California. This scale has been considered to be freer from parasites than any of the other citrus fruit scales. While this, in general, is true, yet in certain places the purple scale is as heavily parasitized as the red or yellow, and the parasite in question has been known to occur in the State since 1891. But in many sections of the citrus belt where the purple scale occurs, little or no trace of this parasite will be seen. In sections, as Whittier, where fumigation is so generally practiced as it was in 1910 (98 per cent of the acreage) there is no doubt about its effect on the parasites. In considerable purple scale material collected from this vicinity during the past two or three years, there have been but occasional instances where parasites were obtained. But just outside the Whittier section, where trees infested with purple scale had never been fumigated or sprayed, as high as 30 per cent or 40 per cent of the scales at one time were found parasitized.

This same fact holds true for the yellow scale parasite, for it is the same parasite that attacks both scales. Yellow scale material has frequently been obtained from sections where fumigation is generally practiced, but none or few parasites were secured. But yellow scale material taken from Santa Barbara County, and in the northern sections where no fumigation is practiced, had a considerable percentage of the scales parasitized in many instances.

### *Aspidiotiphagus citrinus* Craw.*

*Aspidiotiphagus citrinus* Craw. is the only parasite that we have taken thus far from the purple scale. This is the insect referred to above, and, while occurring in certain limited localities in considerable numbers, it is not common throughout the purple scale belt. This is a strictly internal parasite and attacks the scale only between the first and second molt. The scale has shed its first skin and approaches very nearly the time when it should cast its second skin. But thus far no instance has been observed where the scale had actually molted the second time.

The egg is deposited within the insect and there hatches a very minute, white larva, with a tail-like appendage. This is afterward lost, and as the larva becomes mature it is about .85 mm. long and .35 mm. wide, tapering slightly toward the anterior and more strongly toward the posterior end. It pupates within the scale, the pupa at first being white or light colored but later turning very dark. The adult makes its way out through a circular exit hole in the posterior one third

*For a more detailed account of this parasite, see Cal. Exp. Sta. Bull. 222.

of the scale, these being found only in the partly grown scales. The age of the scale when grown is stopped by the effects of the parasite, judging entirely from the condition of the scale, appears to be about forty or forty-five days, when the second molt would occur in about fifty or fifty-five days. During the past two years a large number of these parasites have been found issuing in December. This may be on account of the fact that the scales are, or have been, in the proper stage for attack.

## PREDACEOUS ENEMIES.

The several species of native *Coccinellidæ,* together with the larva of *Chrysopus* and *Hemerobius,* may all attack the purple scale as well as other scale insects. But the one *Coccinelid* that has been seen most frequently attacking the purple scale is *Rhizobius lopanthæ.* This species also occurs commonly on the red scale. The larva of this beetle is distinguished by having rectangular areas of light gray on the otherwise dark dorsal surface. When full grown it is 4 mm. long and about 1 mm. wide. The adult beetle measures from 2 to 2½ mm. in length, and is black in color with a strong metallic luster.

*Scymnus marginicollis* Mann. is another species that is often found with the purple scale. This beetle is similar in size to that of *R. lopanthæ,* but is of a dull black color instead of the metallic bronze-like luster of that of *lopanthæ.*

## RELATED SPECIES.

Aside from the species *beckii,* there are three others recorded from California as belonging to the genus *Lepidosaphes.* These are *L. gloverii* Pack., *L. ulmi* Linn., and *L. crawii* Ckll. *L. crawii* has been recorded only from the oak and *Elæagnus,* and is therefore of no economic importance. *L. ulmi* is the common and widely distributed oyster-shell scale and occurs on many deciduous fruit trees. In the shape and appearance of the scale covering, it closely resembles the purple scale, but if the insect itself be examined it is readily distinguished by the fact that the lobes are not serrate as in the case with *L. beckii. L. gloverii* or Glover's scale is the other member of the genus that is primarily a citrus fruit scale. It has been only rarely met with in California, while in Florida it is of very common occurrence. This scale covering is much more linear in shape than the purple and is not so often curved. The distinguishing characters of the insect itself are that the lobes are pointed and are not serrate.

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A. J. GAUMNITZ, M.S., Assistant Agronomist, University Farm, Davis.
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P. L. MCCREARY, B.S., Chemist in Fertilizer Control.
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F. C. H. FLOSSFEDER, Assistant in Viticulture, University Farm, Davis.
P. L. HIBBARD, B.S., Assistant Fertilizer Control Laboratory.
C. H. MCCHARLES, M.S., Assistant, Agricultural Chemical Laboratory.
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WALTER E. PACKARD, M.S., Field Assistant Imperial Valley Investigation, El Centro.
S. S. ROGERS, B.S., Assistant Plant Pathologist, Plant Disease Laboratory, Whittier.
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W. H. VOLCK, Field Assistant in Entomology, Watsonville.
E. L. MORRIS, Field Assistant in Entomology, San Jose.
E. E. THOMAS, B.S., Assistant Chemist, Plant Disease Laboratory, Whittier.
A. B. SHAW, B.S., Assistant in Entomology.
G. P. GRAY, M.S., Chemist in Insecticides.
H. D. YOUNG, B.S., Assistant in Agricultural Chemistry, Plant Disease Laboratory, Whittier.
A. R. TYLER, B.S., Assistant in Plant Pathology, Plant Disease Laboratory, Whittier
W. V. CRUESS, B.S., Assistant in Zymology.
J. F. MITCHELL, D.V.M., Assistant in Veterinary Laboratory.
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F. H. WILSON, B.S., Assistant in Soil Chemistry.
W. M. MERTZ, Assistant in Pomology, Riverside.
ANNA M. LUTE, A.B., Scientific Assistant U. S. Department of Agriculture.
J. C. ROPER, Patron, University Forestry Station, Chico.
E. C. MILLER, Foreman, Forestry Station, Chico.
D. L. BUNNELL, Secretary to Director.

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# ENOLOGICAL INVESTIGATIONS

## I. INTRODUCTION.

Special investigations in viticulture and enology have been pursued by the Viticultural Division of the College of Agriculture in fulfillment of the requirements of an act passed by the legislature of the State of California in 1909. Details of the purposes of this act are given in the introduction to Bulletin 213. In accordance with the provisions of this act the following publications have been issued:

1. Grape Growing in the Imperial Valley. In Bulletin 210, January, 1911.
2. The Principles of Wine-making. Bulletin 213, May, 1911.
3. The Extermination of Morning-Glory. Circular 69, August, 1911.
4. Hot-room Callusing. Circular 76, August, 1911.

The legislature of 1911, confirming the act of 1909, continued the appropriation to carry out its provisions. Two publications, including the present bulletin, have been issued as the result.

5. Grape Vinegar. Bulletin 227, January, 1912.
6. Enological Investigations. Bulletin 230, June, 1912.

The principal improvements in the art of wine-making contributed by the last twenty-five years are the accurate and intelligent use of sulfurous acid, the application of pure yeast to the fermentation of grapes and the control of the temperature in every stage of the process.

The proper use of sulfurous acid has made it possible to avoid completely the production of spoiled wines. No wine-maker who understands this use and applies his knowledge has any vinegar-sour, lactic, mousey, slimy, or otherwise diseased wines in his cellar. High volatile acid, unfermented sugar, persistent cloudiness, defects due in nearly all cases to bacterial growth can be completely eliminated. It enables him to have every gallon of his wine sound, dry and clear within three months or less from the crushing of the grapes. This is, therefore, the first and most important improvement in his art that the wine-maker should study.

The application of pure yeast is perhaps the next. It is the complement of the use of sulfurous acid. It may not in every case enable him to improve his best wine, but it will give much greater certainty to his operations and undoubtedly improve the average quality and increase the uniformity of his product. It prevents those strange varia-

tions of quality between casks of wine made from the same grapes by the same methods which have so long puzzled wine-makers.

The control of temperature is the final improvement which gives him absolute control over every detail of the wine-making process. In addition to the two other means, it enables him to reduce his operations to an exact method and to eliminate chance. By use of all three, he can lay out his work with a precision and certainty unknown to the old forms of wine-making. By restricting the rise of temperature during the violent fermentation and maintaining it during the after fermentation the delicacy and the finer qualities of the wine can be greatly improved. Refrigerating the wine to a suitable degree after the elimination of the sugar promotes its rapid clarification by the precipitation and deposition of salts, micro-organisms and the other solid matters which often form a persistent cloudiness in defectively handled wines. A proper rise of temperature after the wine has been cleared by the first or second racking, hastens and facilitates the maturing of the wine. The time and degree of this rise are determined by the degree of aging desired. When this is obtained, a lowering of the temperature makes it possible to keep the wine without depreciation until it can be brought by subsequent finings, rackings and other operations into the condition required by the consumer.

The general principles and practice of these improvements have been discussed in Bulletin 167, "The Manufacture of Dry Wines in Hot Countries"; Bulletin 213, "The Principles of Wine-making"; Circular 22, "Defecation of Must for White Wine"; and Circular 23, "Pure Yeast in Wineries." Experiment work on their applicability to Californian conditions has been reported in Bulletin 174, "A New Wine-cooling Machine," and Bulletin 177, "A New Method of Making Dry Red Wine."

Cooling devices have been installed in a large number of Californian wineries and their utility is very generally recognized by our wine-makers. Pure yeast has been used with success for several years in a limited number of wineries in the State and would become more general if its merits and ease of application were better understood. Sulfurous acid has rapidly come into very general use, but many wine-makers have an imperfect understanding of its effects and of the best methods of use.

The present bulletin is an attempt to popularize the last two improvements and to clear up some uncertainties regarding their use.

Investigations were made during the last season to determine to what degree the injurious micro-organisms could be eliminated and the wine yeast encouraged by the use of sulfurous acid and pure yeast and to discover the best methods and doses in various cases. Some of

these investigations were conducted in the laboratory and some at the winery of Mr. J. E. Colton, who very obligingly offered us the necessary facilities. Some tests were made on a scale large enough to demonstrate their applicability to industrial conditions in California, and to determine how much improvement could be expected from the use of sulfurous acid and pure yeast, which are easily and cheaply applied without the asistance of cooling devices which require more trouble in applying and more expense in installing.

## II. SULFUROUS ACID IN WINE-MAKING.

### A. General Considerations.

(a) *Historical.*—The use of sulfurous acid in wine-making, dating from remote antiquity has within recent times undergone remarkable developments.

The Romans used sulfur to mix with the pitch, wax, incense and spices which they steeped in their wine or burnt in the vessels in which they stored it. The literature of more modern wine-making contains numerous favorable references to the utility of the fumes of burning sulfur for the treatment of casks in which wine was to be kept. Many authors recommended the addition to the sulfur of orris root, ginger and similar aromatic substances. Such additions were doubtless a survival of the ancient practices and show that wine-makers were still ignorant of the true nature of the action of sulfur fumes.

(b) *Modern Developments.*—Only within the last twenty-five years have we begun to formulate a correct theory of the effects, beneficial and injurious, of "sulfuring," enabling us to make use of the former while avoiding the latter. The development of this theory we owe to the general progress of applied science and especially to the researches of Nessler, Weigert, Strucchi, Bouffard, Martinand, Laborde, Wiley and many others who have investigated the practice from the chemical, industrial, and hygienic sides.

At present, sulfurous acid is used in some form and for some purposes in every winery and every wine cellar where good wine is made and where anything but the most primitive and elementary notions of the art of wine-making exist.

(c) *Opinions of Experts.*—Babo and Mach, in the last edition (1910) of "Kellerwirtschaft," the principal work on wine-making in the German language, say: "Sulfuring is indispensable." "In cellars where the practice is unknown, it is hard to find completely sound or merchantable wines." J. Weinmann, in the last edition of "Manuel du Travail des Vins Mousseux," recommends the use of 3 to 5 grams

of bisulfite of potash per hectoliter of must in the manufacture of champagne. L. Mathieu, speaking for Burgundy, says (1911) "Wine of the highest quality is obtained by the previous sulfuring of the must." J. Laborde, discussing the preparation of the white wines of the Gironde, states, (1910), "The use of sulfurous acid in white wine is a benefit—even a necessity." E. Dupont, giving the results of his observations on the use of sulfurous acid in the south of France, says (1910), "The practice should become a part of the general method of wine-making," and further, "We are obliged to recognize that since the use of sulfites in the fermenting vats has become general, the number of badly made, defective or diseased wines, formerly so frequent, has diminished considerably; in fact, such wines have almost disappeared from commerce." Finally, at the International Congress of Madrid (1911) five resolutions were adopted having reference to the improvement of wine and its methods of manufacture. Three of these resolutions speak in favorable terms of the use of sulfurous acid and the other two recommend methods which are based on its use.

Among modern authorities there are but few dissenting opinions, and these come from chemists or medical men who have little or no knowledge of wine, and whose views are based on observations of the action of sulfurous acid in cases where the objects and effects are totally different from those of its proper use in wine-making.

It may be taken as demonstrated, therefore, that to obtain the best wine from the point of view both of the producer and of the consumer, the rational use of sulfurous acid is necessary. No substitute has yet been found of which the efficiency has been demonstrated. There are serious objections to all which have been proposed and none of them accomplish all the desirable objects attained by the use of sulfurous acid.

(d) *Legal Limitations.*—In order to obtain these results, however, it is necessary that the wine-maker should understand clearly how the sulfurous acid acts and the limits within which it must be used. A lack of this understanding on the part of the wine-maker and a confusion of the effects of the free acid with those of the combined acid, as it occurs in wine, on the part of earlier investigators has led to legal limitations on its use. These limitations were at first so narrow as practically to prohibit its use, but with increasing knowledge of the facts, they have been gradually widened until they are now sufficient to cover all the amounts which the intelligent wine-maker needs. The present tendency of pure food laws seems to be to place the limitations at about .035 per cent or 350 milligrams per liter of total sulfurous acid of which not more than 70 milligrams may be free. There is no need ever to exceed these limits, and the wine-maker who does so will in

most cases injure the quality and merchantable value of his wine irrespective of the legal limitations. For the protection of the consumer there is little need of legal limitations, as an excess which approaches an amount harmful to the consumer will so depreciate the selling value of the wine that the abuse would tend to cure itself. The establishment of legal limits, however, has been of great use to the wine-maker by making it necessary for him to study carefully the methods of applying sulfurous acid, and of graduating the amount to the case in hand in order to obtain the maximum beneficial effects.

### B. Properties, Preparation, Use and Effects of Sulfurous Acid.

(a) *Properties.*—Sulfurous acid ($SO_2$) is a colorless gas 2.2 times as heavy as air, easily recognized by its characteristic odor. Sulfur itself has no odor and the so-called "sulfur smell" is due to the $SO_2$ produced when sulfur is burned.

The gas is soluble in water in the proportion of 30 to 45 volumes at ordinary temperatures. At the temperature of 20° C. one volume of water will dissolve 36.4 volumes, or one pound of water will dissolve .104 pounds of the gas. The gas liquefies at ordinary atmospheric pressure when its temperature is lowered to —10° C. At the temperature of 20° C. it exerts a pressure of 3.25 atmospheres or 40.6 pounds per square inch.

Sulfurous acid gas will not burn like hydrogen or illuminating gas nor support combustion like air or oxygen.

It has a bleaching action on organic colors which is sometimes utilized in decolorizing fabrics, nuts, dried fruits, etc. It owes this property to its power of forming colorless compounds by combining with the coloring matters. These compounds can usually be broken up by oxidation and the color restored. Pink must or wine can be made white by treatment with $SO_2$, but on aeration the color returns. The bleaching action thus differs materially in character from that of chlorine which destroys the color, or that of charcoal which removes it.

When dry it is inactive. In the disinfection of rooms, the air is first saturated with moisture by means of steam which allows the $SO_2$ to exert its germicidal properties.

Compounds are readily formed by $SO_2$ with certain organic substances called aldehydes of which formaldehyde and acetaldehyde are typical. The latter occurs in wine together with others similar in very small quantities. These compounds are what are known as the "combined" form of $SO_2$ as it occurs in wine. This property has been utilized for the removal of $SO_2$ from wine by the addition of urotropine. This substance acts by breaking up slowly with the evolution of for-

maldehyde. As the latter is harmful, the process is useless and illegal when applied to wine.

Similar combinations take place between $SO_2$ and the sugar of grape must. These combinations are fairly stable and they seem to constitute the main part of the combined $SO_2$ in grape must.

When introduced into wine or grape must, some of the $SO_2$ fails to enter into any of these combinations. It is this part which is called the "free" $SO_2$. It is this form which has the active antiseptic and germicidal properties utilized in wine-making. It is also this form which in excess is harmful to animals and men who consume excessively sulfured products, and to plants growing in the vicinity of factories which give off "sulfur fumes."

In solution in water, it readily attacks alkalies, metallic oxides and most metals, forming salts termed sulfites, bisulfites, and metabisulfites, according to the proportion of $SO_2$ which they contain. Dissolved in water, therefore, it is a true acid. Its acid properties are weak, that it to say, it is readily liberated from its salts by other acids such as sulfuric, tartaric, citric, and acetic. This explains the odor of burning sulfur given off by a fermenting vat when the grapes have been treated with metabisulfite. The $SO_2$ is set free by the tartaric acid of the must.

(b) *Preparation and Use in Wineries*: 1. SULFUR FUMES.—When sulfur is burned in the air, oxygen is taken up and sulfurous acid gas is formed. The chemical reaction involved is expresed thus:

$$S + 2O = SO_2.$$

Sulfur+2 Oxygen=Sulfurous acid.

This is the reaction which takes place when a cask is disinfected by burning a piece of sulfur tape. Sulfur wicks or matches are made by coating strips of asbestos or of thin linen or cotton cloth or of tough paper with sulfur. The fabric is cut into strips about 1¼ inches wide and 10 or 12 inches long. These strips are then dipped into melted sulfur kept at the lowest temperature at which it will remain liquid. By dipping two or three times and allowing the sulfur to harden between times, a thick coating of sulfur can be obtained. As the burning of the cloth core produces ill-smelling fumes the smaller the proportion of cloth to sulfur the better.

When used for sulfuring small casks, these wicks are usually suspended by means of a sulfur bung and burnt in the cask. A sulfur bung consists of a wooden bung sufficiently long and tapering to fit all sizes of bung holes, and furnished with a piece of iron wire 10 inches to 15 inches long inserted in the bottom of the bung at one end and turned up to form a sharp hook at the other.

There are several serious objections to using sulfur in this way. Part of the sulfur melts and falls to the bottom. If it burns there, it injures the staves of the cask, if it fails to burn it may communicate a bad taste to the wine. Part volatilizes and is deposited as fine flowers of sulfur on the walls of the cask where it may later be changed into hydrogen sulfide by the action of yeast. Hydrogen sulfide is the cause of the "rotten egg" smell of some wines which is the same as that familiar at sulfur springs. Another portion of the sulfur forms evil-smelling compounds with the cloth core of the wick and still another portion is oxidized to *sulfuric* acid, $SO_3$.

To prevent the falling of the molten sulfur to the bottom of the cask the sulfur wick may be burned in a "sulfur cage," consisting of a narrow metal or earthenware cylinder with perforations on the sides

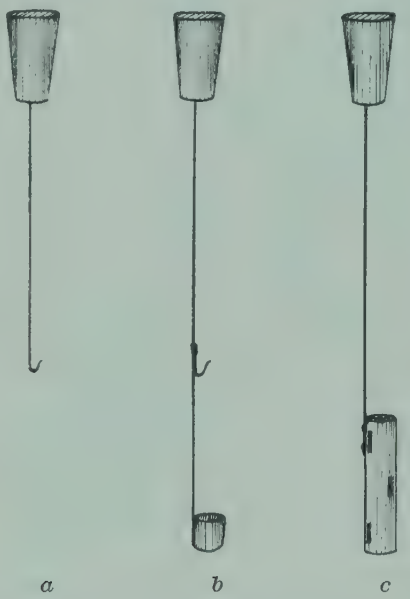



FIG. 1.—Devices for burning sulfur in casks.
*a*, sulfur hook; *b*, sulfur cup; *c*, sulfur cage.

to admit air. This cage has a solid bottom to catch the melting sulfur and is suspended in the cask by means of a sulfur bung. Sulfur cups of similar design are made in which the sulfur can be burnt directly and the defects due to burning cloth obviated. The latter are not very convenient to use, however, except where very small quantities of sulfur are needed. In sulfuring large casks furnished with a manhole at the bottom, the sulfur is usually burned in an iron or earthenware pan on the bottom of the cask. This pan should be supported by a brick or other means of protecting the staves from the heat of the burning sulfur.

Various devices for sulfuring are in use in which the sulfur is burned outside of the cask. One of these consists of a barrel from which one

head has been removed. It is inverted over a pan in which the sulfur is burned. Air is admitted through holes near the ground and the sulfur fumes introduced into the must or wine by means of an air pump connected with the top of the barrel and the cask to be sulfured. The sulfur fumes quickly corrode a metal pump. See Fig. 2.

A better type of sulfuring machine and one in more common use is illustrated in Fig. 3. It consists of a stove in which the sulfur is burned connected with a tall cylindrical vessel in which the sulfur fumes are brought into intimate contact with the must. The heated gas and air entering the bottom of the cylinder pass over the surface of the must, which flows over a series of inclined plates and the whole

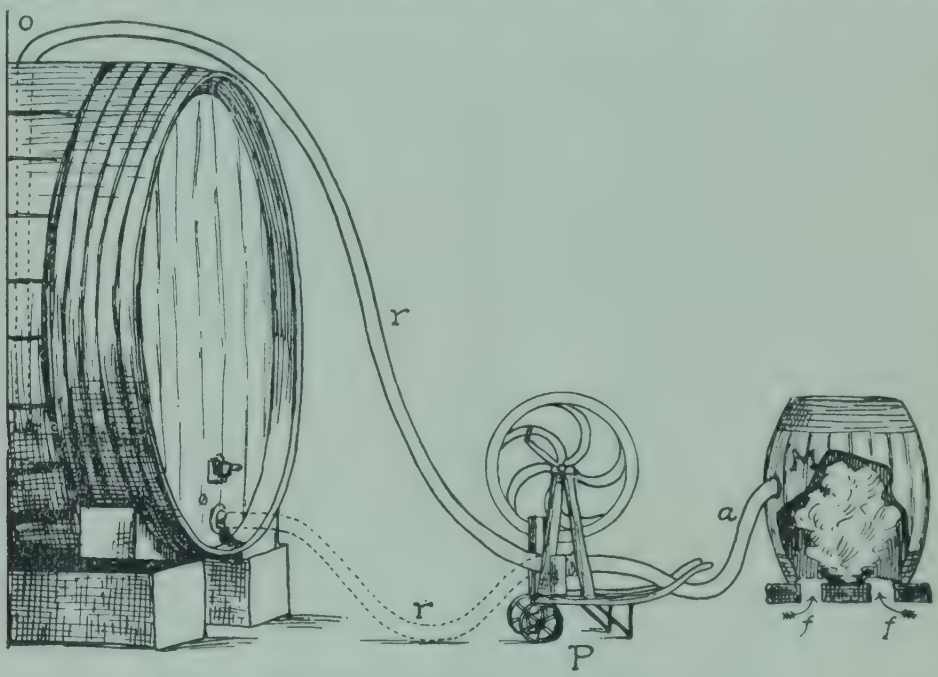



FIG. 2.—Method of sulfuring must with a pump.

M, small cask with one head removed, serving as a chamber in which to burn the sulfur; *f*, *f*, openings for entrance of air; *a*, *r*, hose through which the sulfur fumes are forced into the cask of wine by means of the pump, P.

of the $SO_2$ produced is absorbed. By interposing a water trap between the stove and the cylinder, and forcing the fumes through this trap by means of an air blast, the volatilized sulfur and sulfuric acid may be removed.

This device removes most of the objections cited above, but the extreme uncertainty of measuring and the difficulty of regulating the amount of $SO_2$ introduced into the must still exist.

A device for partially removing these objections consists of a turbine turned by the must which flows over it. This turbine operates a fan which supplies the air to the sulfur stove. As the rapidity of the turbine varies with the rate of flow of the must, and the $SO_2$ produced

varies with the amount of air passing through the stove, a means of regulating the amount of $SO_2$ in accordance with the volume of must is afforded.

With even the most perfect of these devices, one other serious defect of the method of obtaining $SO_2$ directly from burning sulfur remains. This is the extreme uncertainty of the amount of $SO_2$ produced by burning a given weight of sulfur.

According to the formula of the reaction, one part by weight of sulfur

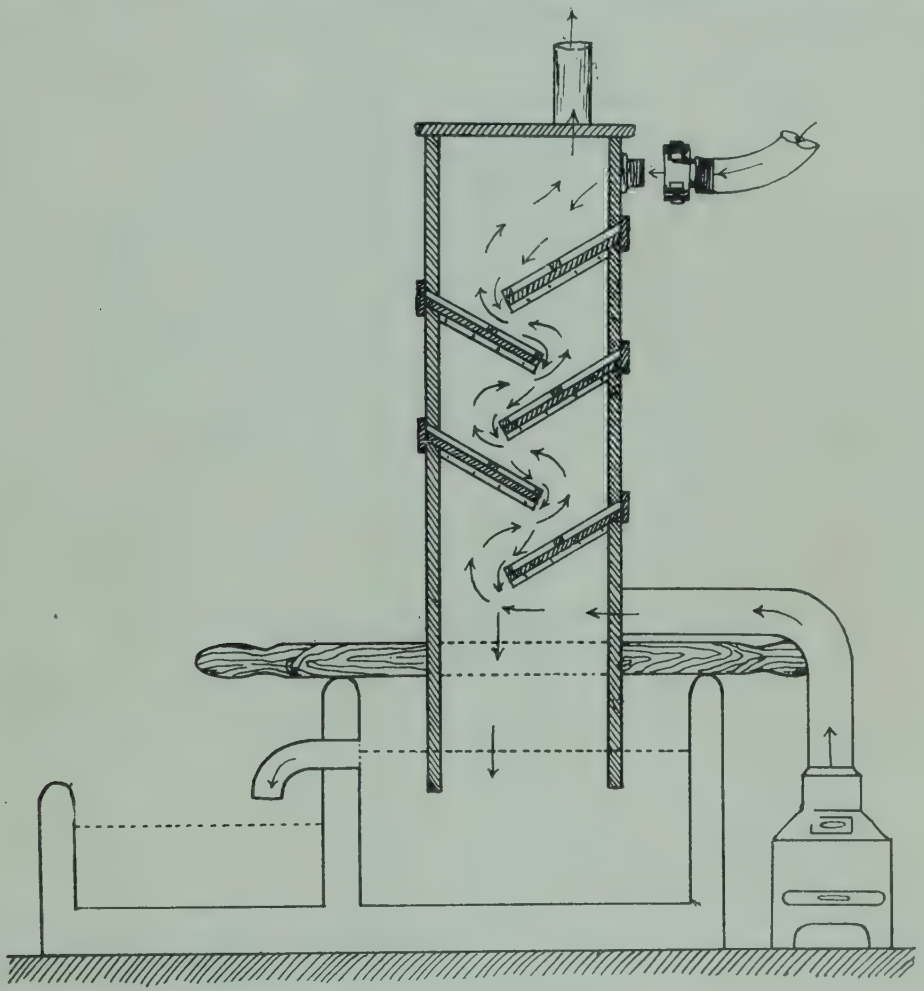


FIG. 3.—Sulfur machine.

on burning should yield two parts by weight of $SO_2$, or one ounce should yield .782 cubic feet of the gas at 60° F.

In practice the yield is much less than this. Pacottet states that the quantity of $SO_2$ actually formed when sulfur is burned in a small cask varies from 15 per cent to 60 per cent of that corresponding to the amount of sulfur consumed. This loss is due to the sulfur which is volatilized or melted without burning and to that which forms sulfuric acid. It varies with the amount of sulfur burnt in a given space

and with the mechanical condition of the sulfur. When there is a full supply of air and when the sulfur is well exposed to it, the combustion is more perfect. As the air becomes exhausted of its oxygen, combustion becomes less perfect. When all the sulfur possible is burned in a closed space, a greater proportion is lost than if a smaller quantity is burned.

When only a very small quantity of $SO_2$ is needed, as in racking wine, and careful methods of burning are used, the weight of sulfur may be taken as a fair measure of the $SO_2$ produced which may be as high as 85 per cent* of the theoretical amount. When larger quantities are needed, the weight of sulfur used becomes a very uncertain measure of the $SO_2$ obtained. When the larger quantities are needed, as in the defecation of must, it is interesting to know what is the maximum amount of $SO_2$ that can be produced in a cask by burning sulfur. By using an excess of sulfur that lost by volatilization and melting does not come into the account.

A cask or other closed space contains a certain amount of oxygen which, if it combined with sulfur would produce exactly twice its weight of $SO_2$. This we will call the theoretically possible yield which is about .6 grams to 1,000 c.c. of air at 0° C. In practice, the possible yield is much less than this. The difference is caused by losses of oxygen, some of which combines to form sulfuric acid, some escapes from the barrel as the air expands with the rise of temperature and some fails to combine when the proportion in the air becomes too small to support the combustion of the sulfur.

These facts are shown by the results of tests given in the following table:

TABLE No. 1.

*$SO_2$ produced by burning sulfur in a closed space.*

| | Volume of vessel. | Sulfur used. | Sulfur melted. | Sulfur sublimed. | $SO_2$ formed. | Sulfur utilized. | Oxygen utilized. |
|---|---|---|---|---|---|---|---|
| 1. | 3700 c.c. | .180 | 0.0 | .0494 | .2613 | 72.6% | 11.6% |
| 2. | 3700 c.c. | .520 | 0.0 | .1790 | .6830 | 65.7 | 30.4 |
| 3. | 3700 c.c. | .600 | .08 | .1880 | .8241 | 68.7 | 36.6 |
| 4. | 3700 c.c. | 1.300 | .56 | .3050 | .8710 | 33.5 | 38.7 |
| 5. | 3700 c.c. | 2.290 | 1.68 | .2150 | .7900 | 14.2 | 35.1 |

Test No. 1 represents the burning of a little more than 6 ounces of sulfur in a 1,000 gallon cask. Nearly three fourths of the sulfur is oxidized to $SO_2$ and about one tenth of the oxygen of the air is utilized. As we increase the amount of sulfur used we gradually approach a maximum production of $SO_2$ which corresponds to about 1.5 pounds to 2 pounds of sulfur in a 1,000 gallon closed cask and utilizes a little

* Laborde.

more than one third of the oxygen present. If we use more than this maximum the excess of sulfur simply melts or sublimes and no more $SO_2$ is produced unless we renew the air in the cask.

Another element of uncertainty in this method of sulfuring is the failure of the must to take up all the $SO_2$ produced in the cask. Some of it always escapes with the air forced out of the cask by the incoming must. This loss is increased with the rapidity of filling, it is greater when the must is introduced at the bottom of the cask and when it enters in a solid stream. It is greater usually in small casks than in large. It can be diminished by filling the cask slowly and especially by introducing the must in a spray by means of a rose-nozzle or similar device.

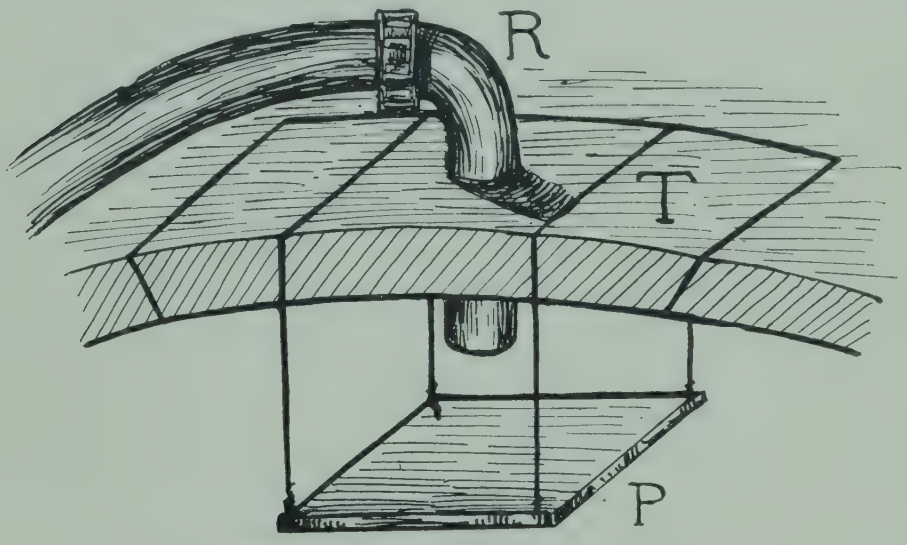



FIG. 4.—Device for spraying must into sulfured cask.

R, hose for entrance of wine; T, cover of manhole to which is attached by cords a small piece of wood, P, on which the entering wine strikes and is broken up into a spray.

In small casks it can be almost eliminated by first introducing a small quantity of must, 5 per cent to 10 per cent of the total, and then rolling the cask until all the $SO_2$ has been absorbed and filling with the rest of the must.

An idea of the amount of loss by failure of all the oxygen to combine to form $SO_2$ and by escape of a portion of that formed is given by the following experiments. In wooden barrels of various sizes and in glass flasks holding 2,600 c.c. all the sulfur possible was burned. Each was then filled with water, must or wine, run in slowly. As soon as full, the amount of $SO_2$ in the liquid in each vessel was determined with the results shown in Table 2.

TABLE No. 2.

*Absorption of $SO_2$ with maximum sulfuring.*

| Container. | Liquid. | Per cent $SO_2$ absorbed. | Theoretical yield. | Ratio to theoretical yield. |
|---|---|---|---|---|
| 2600 c.c. flask | Water | .00796 | .0546 | 14.38% |
| 2600 c.c. flask | Water | .00948 | .0546 | 17.34 |
| 2600 c.c. flask | Water | .00920 | .0546 | 16.85 |
| 2600 c.c. flask | Must | .00535 | .0546 | 9.79 |
| 2600 c.c. flask | Must | .00504 | .0546 | 9.23 |
| 2600 c.c. flask | Must | .00663 | .0546 | 12.14 |
| 2600 c.c. flask | Wine | .0154 | .0546 | 28.51 |
| 5 gallon barrel | Water | .0133 | .0546 | 24.17 |
| 5 gallon barrel | Water | .0126 | .0546 | 23.07 |
| 28 gallon barrel | Water | .0142 | .0546 | 26.01 |
| 28 gallon barrel | Water | .0168 | .0546 | 30.76 |
| 28 gallon barrel | Water | .0132 | .0546 | 24.17 |
| 50 gallon barrel | Water | .0118 | .0546 | 21.43 |

From Table No. 2 it is seen that wine absorbs the gas more readily than water and water in turn is a better absorber of $SO_2$ than must. The averages for each in a 2,600 c.c. bottle are: water 88.8 milligrams, $SO_2$ per liter, must 56.7 milligrams per liter and wine 154 milligrams per liter. The per cent of sulfurous acid absorbed in the barrels was greater on the average than in the glass bottle, owing no doubt to the relatively greater surface exposed in the wooden containers, due to the inequalities of the surface and pores of the wood. The film of water in the pores, etc., absorbs the $SO_2$ rapidly. The figures indicate that by burning a maximum amount of sulfur in small barrels and running in the liquid by means of a plain hose the must or wine will be sulfured at the rate of 50 to 150 milligrams per liter.

We may reckon roughly that where all ordinary precautions are taken to make the must absorb all the $SO_2$ produced by burning as much sulfur as possible in a cask, we obtain as a maximum one third of the amount corresponding to the oxygen of the air. This represents a sulfuring of approximately 200 milligrams of $SO_2$ per liter or .02 per cent, corresponding to an addition of 40 grams of potassium metabisulfite to a hectoliter or about 3 pounds to 1,000 gallons of must. This is about the minimum amount necessary in the defecation of must and requires the burning of about 2 pounds of sulfur in a 1,000 gallon cask.

2. *Liquid Sulfurous Acid.*—Gaseous $SO_2$ can be liquefied by pressure or by cooling below —10° C., at which temperature it remains liquid at ordinary atmospheric pressure. The liquid is 1.4 times as heavy as water. It vaporizes rapidly at ordinary temperatures unless confined under presure.

Liquid $SO_2$ is manufactured commercially in Germany from crude sulfur or iron pyrites. The gas obtained by burning the former or roasting the latter is purified by passing through water, which retains

such impurities as sulfuric acid, arsenic, sublimed sulfur and zinc sulfate. The gas is then cooled a few degrees below 0° C. to get rid of the water vapor and finally liquefied by pressure. The pure, dry liquid is then placed in iron cylinders for shipment.

When used in wine-making, some measuring device is necessary. In that constructed by Pacottet, the liquid is forced by the pressure in the cylinder into a small glass measuring tube from which it is allowed to vaporize, through a small copper tube, directly into the must or wine.

The advantages of this method of sulfuring are the great accuracy with which the doses can be measured, the non-corrosive properties of the pure, dry liquid and the absence of such impurities as sulfuric acid, free sulfur and hydrogen sulfide which accompany the $SO_2$ obtained directly from burning sulfur.

3. *Solutions of Sulfurous Acid.* $SO_2$ is soluble in water, which dissolves about 69 volumes at 0° C. The gas is lost rapidly with a rise of temperature and at 20° C. water will hold only 36 times its volume and at 40° C. less than 19. This variability of the water solution makes it entirely unsuited for use in wine-making and its corrosive action on metals and its bulkiness make it inconvenient to handle. It is produced cheaply as a by-product of smelters and in some cases might be used as a disinfectant.

$SO_2$ is more soluble in alcohol, and the solutions, therefore, less bulky. They are, however, also too variable and unstable for use in wine and too expensive for use in disinfection.

4. *Solid Forms; Salts.* Sulfurous acid unites with bases such as potash, soda and lime to form various series of salts of which the principals are the *sulfites, bisulfites,* and *metabisulfites.* These salts all break up with the evolution of $SO_2$ when they are brought in contact with a stronger acid. The tartaric acid of grape must, for example, will combine with the base and liberate the $SO_2$, which is then free to exert its action on the must.

The base in combination with the tartaric acid remains in the must or wine. For this reason the soda and lime salts cannot be used, as they would introduce something foreign to the grapes.

The potash salts on the other hand, introduce only bitartrate of potash or cream of tartar, a normal ingredient of the wine. The amount introduced, moreover, is very small, much less than the variations between different samples of grapes. Any of the pure potash salts may be used, but they differ considerably in strength, cost and convenience.

In potassium sulfite, $K_2SO_3$, the potash is combined with the minimum amount of $SO_2$, of which it contains approximately 41 per cent. The bisulfite, $KHSO_3$, contains when pure, 53 per cent of $SO_2$, but it

loses strength rapidly by oxidation. The metabisulfite, $K_2S_2O_5$, is the strongest of all, containing when perfectly pure and fresh, a little over 57 per cent. It is also more stable than the bisulfites. As found in commerce, it contains only from 50 per cent to 54 per cent and in practice it is usual to consider that the salt will yield half its weight in $SO_2$, which is exact enough for ordinary usages. It will keep fairly constant in composition for months or even years if kept in tightly stoppered glass vessels and in a dry place. For use in wine-making, it should be guaranteed free from all injurious impurities.

It is applied directly in the solid form to the must or made up shortly before using into a 10 per cent solution in water. Water solutions must be made and kept in glass or earthenware vessels, as when concentrated they act very rapidly on metals.

(c) *Transformations of Sulfurous Acid.* The $SO_2$ which is introduced into the must or wine does not all remain free or active. Some of it unites with the sugar and other components of the liquid and becomes more or less inactive in the combined form. Finally, both the free and the combined forms disappear more or less completely and with more or less rapidity. The "total $SO_2$" includes both the free and the combined.

1. DISAPPEARANCE FROM VARIOUS SOLUTIONS. To ascertain the extent and rate of disappearance from various solutions the following tests were made:

TABLE No. 3.

*Disappearance of $SO_2$ from various solutions.*

| Solution. | Time. | $SO_2$ per liter | Solution. | Time. | $SO_2$ per liter |
|---|---|---|---|---|---|
| Water | 0 | 674 m.g. | Water, plus .5% tartaric acid. | 0 | 674 m.g. |
| | 50 hrs. | 630 | | 50 hrs. | 542 |
| | 92 | 541 | | 92 | 395 |
| | 169 | 428 | | 169 | 277 |
| | 288 | 302 | | 362 | 68 |
| | 362 | 231 | | 462 | 40 |
| | 390 | 186 | | | |
| | 462 | 138 | | | |
| Water | 0 | 252 | Water, plus .5% tartaric acid. | 0 | 271 |
| | 26 | 176 | | 26 | 207 |
| | 74 | 25 | | 74 | 143 |
| | 91 | 0 | | 91 | 134 |
| Fresh must, Balling 20%. | 0 | 200 | Raisin must, Balling 24%. | 0 | 200 |
| | 24 | 185 | | 42 | 197 |
| | 39 | 165 | | 72 | 192 |
| | 113 | 125 | | 91 | 166 |
| | 135 | 113 | | 116 | 134 |
| | 543 | 103 | | 140 | 102 |
| | | | | 193 | 96 |
| Raisin must, Balling 24%. | 0 | 600 | Raisin must, Balling 24%. | 0 | 1500 |
| | 18 | 364 | | 42 | 1075 |
| | 42 | 320 | | | |
| | 67 | 262 | | | |

Some of the results of Table No. 3 are shown graphically in Diagram No. 1. The line representing the disappearance of the $SO_2$ from water show that this disappearance is very rapid and almost directly proportionate to the time. The curve of the line of the solution containing tartaric acid is at first steep, gradually becoming flatter. This indicates an increase in the rapidity of loss of $SO_2$ at first and a decrease later. The tartaric acid seems at first to facilitate the escape of $SO_2$ and later to oppose it.

The disappearance is much slower in the musts, showing a retarding influence due to the various substances dissolved in it. The retarding influence varies in the different musts. The raisin must, containing

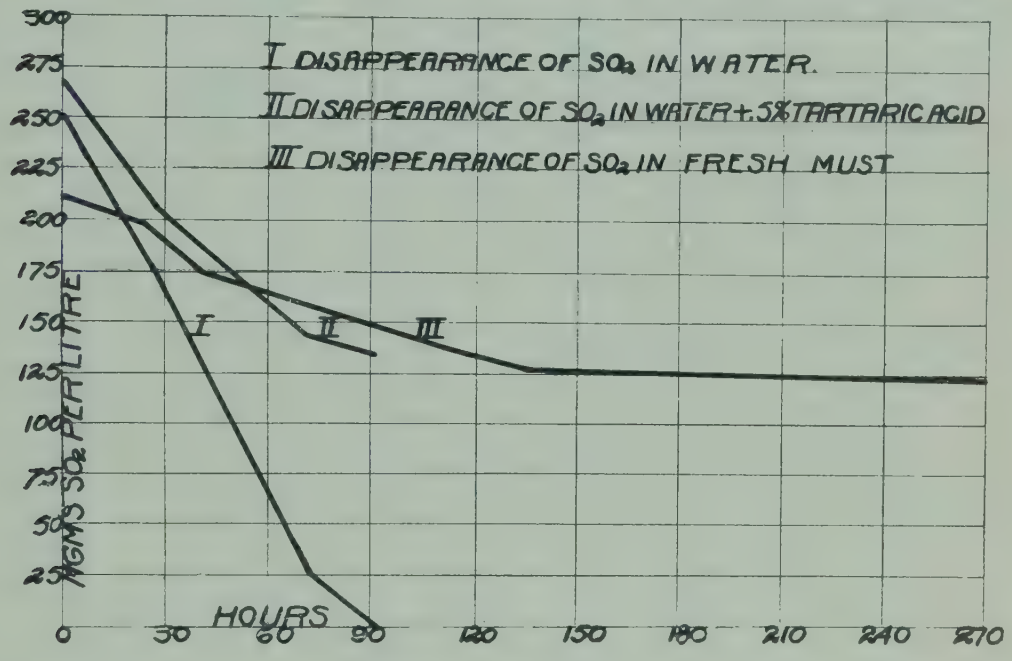



DIAGRAM 1 (see table 3).

Disappearance of $SO_2$ from various solutions.

more sugar shows, at first, slightly more retarding effect than the fresh must. At the end, however, so far as the tests were carried, the raisin must lost slightly more of its $SO_2$.

2. DISAPPEARANCE FROM GRAPE MUST. In spite of the superior retarding effect of the raisin must, it commenced to ferment sooner than the fresh and with a larger total amount of $SO_2$. This indicates a difference in the fermentation restraining power of the $SO_2$ in the two musts. An explanation of this is given in the following tests showing the changes in the amounts of free $SO_2$ in various musts.

These tests, shown graphically in diagram 2, show a much slower disappearance of the active free $SO_2$ from the fresh grape must than from the sweeter raisin must. The results reduced to percentages of free $SO_2$ remaining at various periods are compared in Table 5.

TABLE No. 4.

*Disappearance of free $SO_2$ from various musts.*

| Experiment. | Time in hours. | Free $SO_2$ in milligrams per liter. |
|---|---|---|
| No. 215—Fresh grape must, Balling 20% | Added | 200 |
| | 0 | 175 |
| | 24 | 97 |
| | 39 | 95 |
| | 113 | 70 |
| | 135 | 61 |
| | 168 | 55 |
| | 543 | 2.5 |
| No. 225—Raisin must, Balling 24% | Added | 200 |
| | 0 | 33 |
| | 1 | 30 |
| | 6 | 26 |
| | 25 | 18 |
| | 56 | 12 |
| | 80 | 4 |
| No. 222—Raisin must, Balling 24% | Added | 400 |
| | 0 | 100 |
| | 24 | 35 |
| | 48 | 35 |
| | 78 | 32 |
| | 102 | 14 |
| | 149 | 7.8 |
| No. 222—Raisin must, Balling 24% | Added | 600 |
| | 0 | 116 |
| | 18 | 59 |
| | 42 | 46 |
| | 67 | 23 |
| No. 222—Raisin must, Balling 24% | Added | 1500 |
| | 0 | 269 |
| | 18 | 214 |
| | 42 | 128 |
| | 67 | 58 |

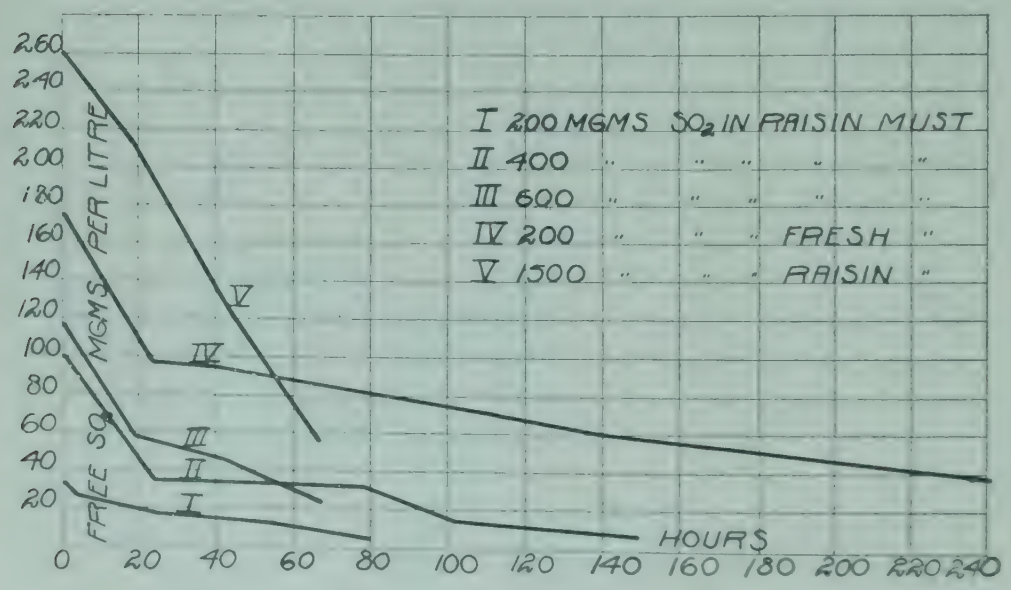



DIAGRAM 2 (see Table 4).

Disappearance of free $SO_2$ from various musts.

TABLE No. 5.

*Free $SO_2$ remaining in fresh and raisin must.*

| | Milligrams per liter added. | Per cent remaining. | | | | |
|---|---|---|---|---|---|---|
| | | On addition. | 36 hours. | 67 hours. | 113 hours. | 168 hours. |
| 1. Fresh must, 20% Balling | 200 | 87.5 | 47.5 | 42.0 | 35.0 | 24.5 |
| 2. Raisin must, 24% Balling | 200 | 16.5 | 7.5 | 4.0 | | |
| 3. Raisin must, 24% Balling | 400 | 25.0 | 8.8 | 8.3 | | |
| 4. Raisin must, 24% Balling | 600 | 19.3 | 8.0 | 3.9 | | |
| 5. Raisin must, 24% Balling | 1500 | 18.0 | 10.0 | 3.9 | | |

The amount of free $SO_2$ in the raisin must seems to be a function of the amount added originally. At the end of three days there was about the same per cent of the original amount present in the must which received only 200 milligrams per liter as in that which received 1,500 milligrams. The fresh must at the same time showed ten times as much. That the free $SO_2$ is the controlling factor in the delay of fermentation is shown by the fact that the raisin must to which 1,500 milligrams was added, started to ferment sooner than the fresh must which received only 200 milligrams. The contrast between the fresh must and the raisin musts is shown clearly in diagram 3.

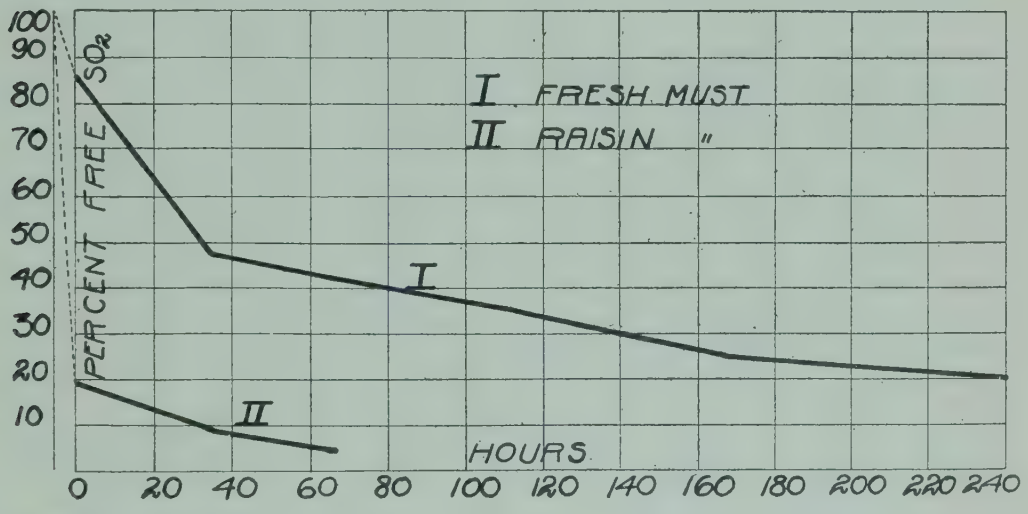



DIAGRAM 3 (see Table 5).—Disappearence of free $SO_2$ from raisin must and from fresh must.

This great difference might be due to the power of some constituent of the fresh must to set the $SO_2$ free or of some constituent of the raisin must to hold it in combination. Tests showed that the $SO_2$ was held equally well in the raisin must when the acidity was raised from .61 per cent to 1.01 per cent, and little difference in this respect could be noticed between raisin musts of 19.5 per cent Balling and 29 per cent Balling. The neutralizing power of the raisin must was found to be

the greater the higher it was heated before the addition, and is apparently due to some undetermined substance formed from the raisin must by the heating.

Differences of neutralizing powers, similar but less marked, have been noticed in practice between different musts, and they indicate one of the reasons for the need of using larger amounts of $SO_2$ in heavy musts made from grapes growing in hot regions where many dried grapes or raisins are apt to occur.

3. WINERY TESTS. Observations were made in a winery to see how nearly the changes in form and amount of $SO_2$ found in laboratory tests corresponded with the actual changes in practice.

Three vats of red grapes containing approximately 10 tons each were tested periodically. No. 169 contained Zinfandel grapes from Acampo showing 22.5 per cent Balling, No. 176, the same grapes showing 22.3 per cent Balling and No. 179 Alicante Bouschet grapes from the same locality showing 22.5 per cent Balling.

TABLE No. 6.

*Disappearance of total and free $SO_2$ from red wine vats.*

| Experiment. | Time in hours. | Balling per cent. | Total $SO_2$. | Free $SO_2$. |
|---|---|---|---|---|
| No. 169—Zinfandel | 0.5 | 22.5 | 219 | 127 |
| | 49 | 23.5 | ---------- | 93 |
| | 64 | 23.5 | ---------- | 90 |
| | 74 | 23.6 | 188 | 90 |
| | 97 | 2.5 | 158 | 50 |
| | 136 | 0 | ---------- | 13 |
| | 181 | 0 | 126 | 11 |
| No. 176—Zinfandel | 0.5 | 22.3 | 75 | 42 |
| | 120 | 0 | 66 | 19 |
| No. 179—Alicante Bouschet | 1 | 22.5 | 186 | 65 |
| | 7 | 22.0 | 169 | 54 |
| | 22 | 19.5 | 159 | 36 |
| | 27 | 15.0 | 150 | 30 |
| | 34 | 10.0 | 131 | 30 |
| | 46 | 3.5 | 119 | 30 |
| | 58 | 0 | 98 | 30 |

From this table we see (Nos. 169, 179) that with an average dose of $SO_2$ for red wine fermentation (200 milligrams per liter or 12 ounces of metabisulfite per ton of grapes) nearly one half of the total disappears during fermentation. With smaller additions (No. 176) a larger proportion remains.

Reference to the curves of diagram 4 shows that the total $SO_2$ disappeared rapidly at first and later more slowly and at a fairly uniform rate. The free $SO_2$ represents at first about 35 per cent of the total.

or 65 milligrams per liter, falling in about seven hours to about 54 milligrams per liter at which point fermentation becomes evident.

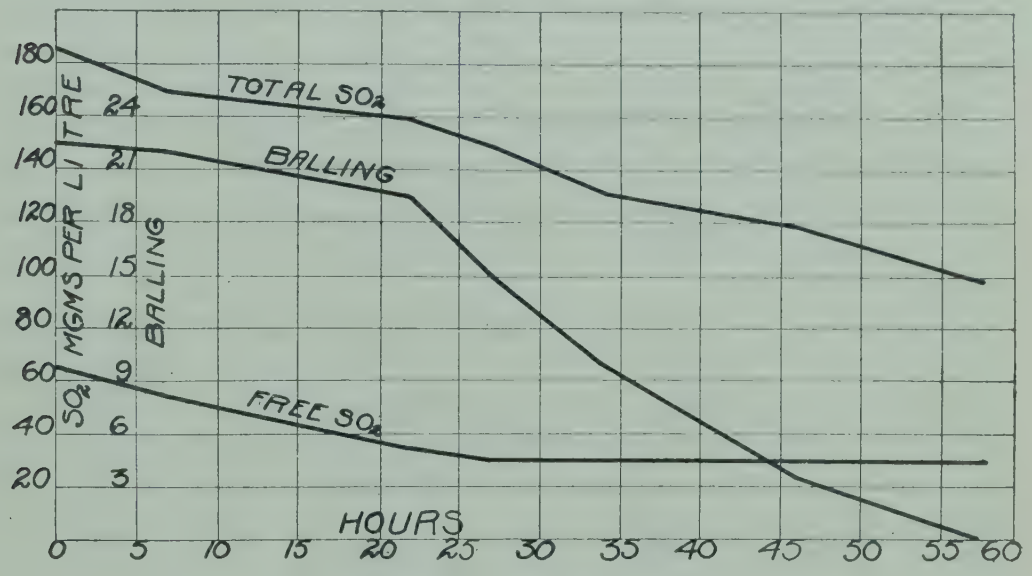



DIAGRAM 4 (see Table 6).

Relation of Balling° to total and free $SO_2$.

4. DISAPPEARANCE FROM WINE. The changes in form and amount are much less rapid in the wine than in the must. Table No. 7 gives the results of determinations of the free and total $SO_2$ made at intervals during one to four months after the completion of fermentation. The decrease is comparatively small in all cases. In some cases there is an increase. This is due to racking into sulfured casks by which the supply was renewed.

TABLE No. 7.

*Disappearance of $SO_2$ from wine after fermentation.*

| Experiment. | Time days after fermentation. | Total $SO_2$ milligrams per l. | Free $SO_2$ milligrams per l. |
|---|---|---|---|
| No. 169—Zinfandel from Acampo | 1 | 178 | 35 |
| | 4 | 170 | 33 |
| | 40 | 115 | 25 |
| | 66 | 96 | 26 |
| | 112 | 76 | 27 |
| No. 170—Zinfandel from Acampo | 0 | 66 | 19 |
| | 74 | 39 | 23 |
| | 120 | 40 | |
| No. 179—Alicante Bouschet | 0 | 98 | 30 |
| | 60 | 96 | 33 |
| | 106 | 108 | 18 |
| No. 181—Green Hungarian, 1500 gallon tank | 2 | 155 | 14 |
| | 28 | 150 | 10 |
| | 74 | 151 | 13 |
| No. 243—Palomino, 185 gallon puncheon | 0 | 312 | 10 |
| | 46 | 340 | 15 |

5. FINAL FORMS OF $SO_2$. The change in the form and amount of $SO_2$ in the fermented wine, as shown in table 7, contrasts noticeably with those which take place in the must before and during fermentation as shown in tables 4, 5 and 6.

When free $SO_2$ is added to must in the quantities usual in wineries either in the form of gas, liquid or sulfite it decreases very rapidly at first. The total $SO_2$ also decreases, but with less rapidity. The combined $SO_2$, on the contrary, increases rapidly at first, the rate of increase gradually slackens, then ceases and finally this form also decreases.

The courses taken by the two forms of $SO_2$ are shown more or less schematically by diagram 5, which represents an average red wine fermentation in an open vat. The 200 milligrams per liter of free $SO_2$ added falls rapidly to between 40 and 50 milligrams in about two and one half days, when evident fermentation starts. The point in time and the amount of free $SO_2$ at which fermentation starts will vary with different conditions of temperature and must composition. During fermentation, lasting in the case supposed about 3 days, the free $SO_2$ continues to decrease with somewhat diminishing rapidity until it reaches about 25 milligrams per liter which amount remains constant for some time.

In the mean while, the combined $SO_2$ has been increasing at a slightly slower rate than the decrease of the free. The difference between the decrease of the free and the increase of the combined is shown by the curve indicating the net decrease of the total $SO_2$.

The final loss of $SO_2$, shown by the decrease in total, takes place

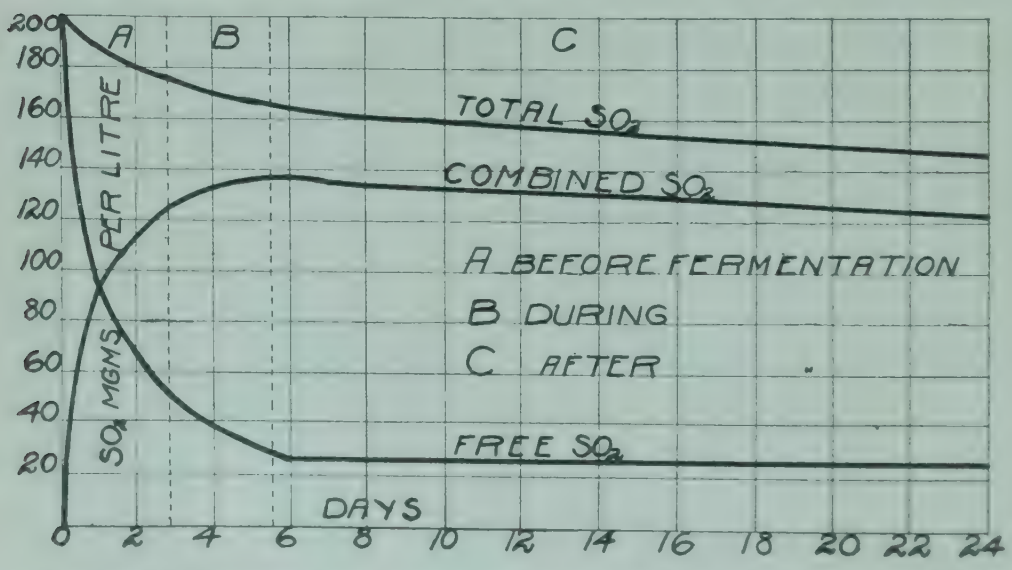



DIAGRAM 5.—Changes in total, free and combined $SO_2$ in must and wine. A. Ante-fermentation period, about three days. B. Fermentation period, about three days. C. Post-fermentation period.

in two ways. Part is volatilized and escapes into the atmosphere, part is oxidized to sulfuric acid. At first the volatilization is rapid and is the principal cause of the loss shown by the steepness of the curve. The escape of gaseous $SO_2$ from a recently sulfited vat is readily recognized by its strong odor. During fermentation the decrease becomes slower, owing probably to a slackening or cessation of the vaporization. After fermentation, the decrease is further diminished owing to the cessation of vaporization and a diminution in the rate of oxidation. In the wine after fermentation, the decrease of total and of combined $SO_2$ is identical. This probably means that as fast as the free $SO_2$ is oxidized, it is renewed by the setting free of an equivalent amount of the combined forms.

The curves of diagram 5 simply represent general or typical forms which may vary in detail in different cases. For example, the change from the free to the combined form will be more rapid in musts from overripe grapes. The rapidity of loss of total $SO_2$ may be much greater than indicated if the must is fermented in small vats with abundant aeration, and it may be much slower if fermented in closed casks of large size. The nature, and causes of some of these variations are discussed later.

The final form of all the $SO_2$ which does not escape into the atmosphere is sulfuric acid. The acid thus produced acts on the cream of tartar giving potassium sulfate and free tartaric acid in small amounts. A measure of the increase in sulfates due to this cause is given by the following tables based on laboratory and winery tests.

TABLE No. 8.

*Increase of sulfates due to use of $SO_2$.* (Laboratory tests.)

| Experiment. | $SO_2$ used milligrams per l. | $K_2SO_4$. | Increase of $K_2SO_4$. | $K_2SO_4$ corresponding to total $SO_2$ added. |
|---|---|---|---|---|
| No. 138—Sultanina | 0 | .0259 | | |
| | 200 | .0421 | .0162 | .0544 |
| | 200 | .0396 | .0137 | .0544 |
| | 300 | .0597 | .0338 | .0816 |
| | 300 | .0550 | .0291 | .0816 |
| Sultanina* | 0 | .0218 | | |
| | 10 | .0230 | .0012 | .0027 |
| | 50 | .0314 | .0096 | .0136 |
| | 75 | .0358 | .0140 | .0204 |
| | 100 | .0388 | .0170 | .0272 |
| | 150 | .0572 | .0354 | .0408 |
| | 200 | .0678 | .0460 | .0544 |
| | 250 | .0766 | .0548 | .0680 |

*Bettoli, R. W. Thesis, 1911.

The increase of sulfates is shown to be approximately proportional to the amounts of $SO_2$ used, but is in all cases less than the amount corresponding to its total oxidation. Even when large amounts are used, (300 milligrams per liter), the increase is not sufficient to approach the legal limit of 2 grams per liter.

Analyses of wines fermented with $SO_2$ in the winery gave similar results.

TABLE No. 9.

*Increase of sulfates due to the use of $SO_2$.* (Winery tests.)

| Experiment. | $SO_2$ used, milligrams per liter. | Sulfates in unsulfited wine. | Sulfates in sulfited wine. |
|---|---|---|---|
| No. 243—Palomino | 600 | .0790 | .0887 |
| No. 169—Acampo Zinfandel | 187 | .0527 | .0548 |
| No. 176—Zinfandel | 185 | .0692 | .0682 |
| No. 181—Green Hungarian | 185 | .0446 | .0564 |
| No. 173—Petite Sirah | 100 | .0225 | .0749 |

These tests show that the variations in the sulfates of different grapes and in different samples of the same grape are much greater than the increases due to the use of sulfurous acid.

In the case of the Green Hungarian musts, the original amount of total $SO_2$ was 185 milligrams per liter. At the time of analysis it was approximately 150 milligrams per liter, indicating a loss of 35 milligrams per liter. The increase in sulfates over the untreated wine was .0118 grams $K_2SO_4$ equivalent to .00305 grams of sulfurous acid or to 30 milligrams per liter. This indicates that most of the $SO_2$ in a white wine fermentation disappears by being oxidized to the sulfate of potash. On the other hand, with the red wine, *c. g.*, the Acampo Zinfandel, only a very small amount of the sulfurous acid is oxidized to the sulfate, indicating that most of it disappears as sulfur dioxide gas or is precipitated in the lees as gypsum; that is, sulfate of lime. The latter is probably the case, for when the wines were examined after racking, that is, six weeks after the above analyses the sulfates had decreased very appreciably in all the wines. A few figures will show this plainly.

TABLE No. 10.

*Loss of sulfates in wine after fermentation.*

| Experiment. | $K_2SO_4$. | | |
|---|---|---|---|
| | December 19, 1911. | February 3, 1911. | Loss, per cent. |
| No. 171—Zinfandel (no sulfite) | .0527 | .0343 | 34.0 |
| No. 169—Zinfandel (sulfited) | .0548 | .0790 | 7.7 |
| No. 176—Zinfandel (sulfited) | .0692 | .0505 | 27.1 |
| No. 173—Petite Sirah (sulfited) | .0749 | .0590 | 21.5 |
| No. 179—Alicante Bouschet (sulfited) | .0571 | .0559 | 2.2 |
| No. 182—Green Hungarian (no sulfite) | .0571 | .0530 | 7.0 |
| No. 181—Green Hungarian (sulfited) | .0608 | .0560 | 8.0 |

(d) *Influence of Composition and Treatment of Must on Fermentation Inhibiting Power of $SO_2$.* Laboratory tests have shown that fermentation does not start in must to which sulfurous acid has been added until the quantity of free $SO_2$ has fallen to an amount which is somewhere between 30 and 50 milligrams per liter.

This reduction in the amount of free $SO_2$ is due to its combination, vaporization and oxidation. It is more or less complete and proceeds with more or less rapidity according to the character of the must and to the treatment to which the must is subjected. Tests were made to determine the influence of various factors on this reduction. The factors investigated were the acid and sugar contents, the presence of pomace and other solid matters, the degree of ripeness of the grapes and the heating of the must to various temperatures.

The tests were conducted in a series of 8 ounce bottles. In each bottle was placed 100 c.c. of must, sulfited to the required degree with a 2 per cent water solution of potassium metabisulfite. The bottles, after inoculation with 1 c.c. of a vigorous culture of Burgundy wine yeast, were kept at a temperature of 30° C. and the start of fermentation determined by the commencement of the evolution of bubbles of gas.

1. ACIDITY. To determine the effect of variations in acidity, a must was used containing 1.18 per cent of total acidity as tartaric. In series *a* the acidity was reduced to .217 per cent by the addition of water, in series *b* to .6 per cent by the same means. In series *c* the acidity was reduced to .63 per cent by means of caustic potash. Series *d* (check) received must without any addition and in series *e* the acidity was increased to 1.8 per cent by the addition of free tartaric acid. In all, the sugar content was made equal to that of the check by means of glucose.

TABLE No. 11.

*Influence of acidity of must on effect of $SO_2$.*

| Experiment. | Acidity. | Number of hours before the start of fermentation. $SO_2$ added in milligrams per liter. | | | |
|---|---|---|---|---|---|
| | | 100. | 150. | 300. | 500. |
| *a* | .217 | 24 hours | 69 hours | 192 hours | 576 hours |
| *b* | .600 | 24 hours | 69 hours | 240 hours | * |
| *c* | .630 | 48 hours | 69 hours | 69 hours | 96 hours |
| *d* | 1.180 | 69 hours | 120 hours | * | * |
| *e* | 1.800 | 48 hours | 192 hours | 336 hours | 576 hours |

*No fermentation.

A diminution of the effect of $SO_2$ with a decrease in acidity is plainly indicated by a comparison of the check *d* with *a* and *b*, in which the acidity had been reduced by dilution with water. This diminution

is much increased in series *c* where the acidity was reduced by neutralization with caustic potash. In series *a* and *b* the ratio between the free tartaric and the bitartrates to which the acidity is due is the same as in the check series *d*. In series *c* the free tartaric had been changed in whole or part to bitartrate. That indicates that free tartaric acid intensifies the effect of the $SO_2$ and explains in part the need of larger amounts in overripe grapes in which little free tartaric acid exists. Some other factor, perhaps experimental error—appears to have influenced series *e*, where the addition of free tartaric does not show an intensification of the effect of $SO_2$ except in the 150 milligram column.

2. SUGAR. The influence of the sugar contents of the must on the effect of $SO_2$ was tested in another must.

To a series of four flasks containing must of 18.1 per cent Balling was added 100, 150, 300 and 500 milligrams per liter of $SO_2$. In a parallel series the must was raised to 22 per cent Balling and in another to 26 per cent Balling by the addition of grape sugar. No differences were noted in the time of starting fermentation. The greater resistance of must made from very ripe grapes, therefore, does not seem to depend on the larger sugar contents.

3. LIMPIDITY. The influence of the presence in the must of undissolved solid matters was next investigated. Series *a* represents a red wine fermentation in which the must ferments in contact with the solid parts of the grape. Series *c* represents a clear must such as might be obtained from clean, sound grapes. Series *b* represents a must from inferior grapes or from a continuous press.

TABLE No. 12.

*Influence of solid matters of the grape on effect of $SO_2$.*

| Experiment. | Number of hours before start of fermentation. $SO_2$ added, milligrams per liter. | | | |
|---|---|---|---|---|
| | 100. | 150. | 300. | 500. |
| *a.* Must and skins | 26 | 26 | 26 | 144 |
| *b.* Cloudy must | 26 | 26 | 240 | * |
| *c.* Filtered must | 26 | 26 | * | * |

*No fermentation.

This shows that the presence of the skins very much diminishes the effect of $SO_2$ and indicates that more should be used in the fermentation of red wine than of white. In a cloudy must the effect is also slightly less than in a clear one and shows one reason for the use of larger quantities with must from moldy or damaged grapes.

4. HEATING. The heating of the must or grapes before fermentation is practised to a limited extent, and the following table shows the influence of various degrees of heating on the effect of $SO_2$. The same must was used in the four series, which were heated to the degrees indicated and then kept at 30° C. The must was heated and cooled before the addition of the $SO_2$.

TABLE No. 13.

*Influence of the heating of must on the effect of $SO_2$.*

| Temperature of Heating. | Number of hours before start of fermentation. $SO_2$ added in milligrams per liter. | | | |
|---|---|---|---|---|
| | 100. | 150. | 300. | 500. |
| 30° C. | 24 | 69 | 120 | * |
| 80° C., 15 min. | 24 | 46 | * | * |
| 100° C., 60 min. | 46 | 46 | 320 | * |
| 120° C., 60 min. | 26 | 26 | 26 | 500 |

*No fermentation.

There seems to be no evidence here that heating to 100° C. has any influence on decreasing the effect of the $SO_2$. It seems, on the contrary, to have tended to delay the fermentation. This may have been due to the expulsion of the dissolved oxygen which was perhaps insufficiently replenished by subsequent aeration. Heating under pressure to 120° C. for an hour, however, had a noticeable influence on decreasing the effect of $SO_2$, added subsequently, resembling in a smaller degree the effect of raisins shown in Tables 6 and 14.

5. RIPENESS. The next tests show the influence of various degrees of ripeness. Series *a* and *b* contained musts made from somewhat underripe grapes, series *c* must from ripe grapes and series *d* a must made from raisins.

TABLE No. 14.

*Influence of degree of ripeness of grapes on effect of $SO_2$.*

| Must. | $SO_2$ added, milligrams per liter. | Hours before start of fermentation. | |
|---|---|---|---|
| | | More than. | Less than. |
| (a) Unripe Rose of Peru | 0 | 0 | 25 hrs. |
| | 50 | 25 | 46 |
| | 100 | 48 | 70 |
| | 150 | 70 | 188 |
| | 200 | 188 | 280 |
| | 300 | 188 | 280 |
| (b) Unripe Tokay | 0 | 0 | 24 |
| | 50 | 24 | 26 |
| | 100 | 26 | 46 |
| | 150 | 26 | 46 |
| | 200 | 46 | 120 |
| | 300 | 120 | 280 |
| (c) Ripe Sultanina | 0 | ---------- | 20 |
| | 50 | ---------- | 23 |
| | 100 | ---------- | 44 |
| | 150 | ---------- | 71 |
| | 200 | ---------- | 92 |
| | 250 | ---------- | 139 |
| (d) Raisins (dried Zinfandel) | 0 | ---------- | 24 |
| | 200 | ---------- | 24 |
| | 400 | ---------- | 24 |
| | 600 | ---------- | 24 |
| | 800 | 24 | 43 |
| | 1000 | 24 | 43 |
| | 1500 | 24 | 43 |
| | 2000 | 43 | 75 |

This table shows marked variations in the influence of different grapes in the effectiveness of the $SO_2$. In the Rose of Peru must 50 milligrams delayed the start of the fermentation as much as 150 milligrams in the Tokay must. The difference between the Tokay and the Sultanina must is not great. The influence of the raisin must in counteracting the effect of the $SO_2$ is remarkable. An addition of 600 milligrams had no apparent effect on the start of fermentation and 1,500 milligrams had less effect than 150 milligrams in any of the other musts. Even 2,000 milligrams delayed the fermentation only about 50 hours, which is much less than the effect of 200 milligrams in the other musts.

These tests show that to obtain a certain effect in wine-making by the use of $SO_2$, the amount necessary to use varies very much with various conditions. Very ripe grapes require from two to three times

as much as moderately ripe or underripe grapes while grapes containing raisins may require even larger amounts. About twice as much is necessary in the manufacture of red wine where the must ferments in the presence of the skins as in white wine where the must ferments alone. Musts from moldy or dirty grapes or very cloudy musts from a continuous press require more than clear musts carefully extracted from clean, sound grapes. The heating of the must seems to have little effect, unless excessive, in which case it may necessitate the use of slightly larger amounts of $SO_2$.

(*e*) *Effects of $SO_2$ on the Micro-organisms of Must and Wine.* 1. COMPARISON OF THE EFFECTS OF FREE AND OF COMBINED $SO_2$. It is a recognized fact that the $SO_2$ which exists free in the must is more active in its effects on micro-organisms than the combined. To obtain data on the relative efficiency of the two forms, pure cultures of a wine yeast were exposed to various amounts of free and to various amounts of combined $SO_2$ for a period of twenty-four hours. The yeast was then transferred to flasks of must containing no $SO_2$, and note taken of the cases in which fermentation started. Where fermentation occurred the yeast had evidently not been killed, where it did occur the yeast had been killed or rendered incapable of developing under the conditions of the experiment.

The free $SO_2$ was obtained by adding various amounts of a solution of metabisulfite to water in which the yeast was placed. The combined form was obtained by adding various amounts of the solution of metabisulfite to raisin must and allowing this must to stand until most of the $SO_2$ had combined before adding the yeast.

TABLE No. 15.

*Comparison of effects of free with those of combined $SO_2$.*

| Exposure to free $SO_2$, milligrams per liter. | | | Exposure to combined $SO_2$, milligrams per liter. | | | | |
|---|---|---|---|---|---|---|---|
| | On addition of yeast, total. | After 24 hours, total. | | On addition of yeast. | | After 24 hours. | |
| | | | | Combined. | Free. | Combined. | Free. |
| *a* | 27 | 23 | *g* | 250 | 4 | 250 | 4 |
| *b* | 50 | 40 | *h* | 652 | 11 | 594 | 10 |
| *c* | 100 | 92 | *i* | 809 | 14 | 716 | 12 |
| *d* | 245 | 220 | *j* | 1019 | 17 | 979 | 17 |
| *e* | 481 | 452 | *k* | 1286 | 22 | 1181 | 20 |
| *f* | 926 | 858 | *l* | 1804 | 31 | 1804 | 31 |

After an exposure for twenty-four hours to the quantities of $SO_2$ indicated in the table, the yeast of each flask was removed to flasks of must where the conditions were made as favorable as possible to fermentation.

The yeast from flask *d* produced fermentation but those from flasks *e* and *f* did not. This indicates that an exposure for twenty-four hours to between 250 and 500 milligrams of free $SO_2$ per liter will kill yeast or render it incapable of development. On the other hand, the yeasts in all the series from *g* to *l* containing combined $SO_2$ fermented without difficulty, indicating that 1,800 milligrams of combined $SO_2$, even when accompanied with a small quantity of free, has no effect on the vitality of the yeast.

A closer approximation to the relative efficiency of the two forms was made by further tests of the same character shown in Table 16.

TABLE No. 16.

*Comparison of effects of free with those of combined $SO_2$.*

| Exposure to free $SO_2$, milligrams per liter. | | | Exposure to combined $SO_2$, milligrams per liter. | | | |
|---|---|---|---|---|---|---|
| | On addition of yeast, total. | After 24 hours, total. | | Amount added, total $SO_2$. | 24 hours after addition of yeast. | |
| | | | | | Combined. | Free. |
| *a* | 253 | 178 | *g* | 2000 | 1426 | 118 |
| *b* | 301 | 230 | *h* | 3000 | 2365 | 277 |
| *c* | 354 | 250 | *i* | 4000 | 3080 | 330 |
| *d* | 424 | 307 | *j* | 5000 | 3894 | 542 |
| *e* | 477 | 477 | *k* | 6000 | 4146 | 896 |
| *f* | 555 | 550 | *l* | 7000 | 5113 | 826 |

The yeast from flask *b*, which contained over 230 milligrams of free $SO_2$, fermented while that of flask *c*, which contained less than 354 milligrams, did not. The amount of free $SO_2$ which will permanently paralyze yeast in twenty-four hours under the conditions of the experiment, therefore, is less than 354 milligrams and more than 230 milligrams.

The yeast from flask *h*, containing over 2,365 milligrams of combined $SO_2$, fermented, while that of flask *i*, containing less than 4,000 milligrams, did not. The flasks with combined $SO_2$, however, contained also smaller amounts of free which must be taken into account in estimating the relative efficiency of the two forms from these figures. Flask *h*, which fermented, contained 277 milligrams of free $SO_2$. If we take 354 milligrams as the amount of free necessary to kill the yeast as indicated by flask *c*, we may reasonably conclude that free $SO_2$ corresponding to the difference between this figure and that of 277, the amount of free $SO_2$ in flask *h*, is more effective than the 2,365 milligrams of combined in the latter flask. The relative efficiency of the two forms in killing yeast seems to be, therefore, somewhere near 77/2365. This indicates that the free $SO_2$ is more than thirty times as effective in this respect as the combined. This figure, however, must

not be considered as anything more than an approximation. It is quite possible that the true ratio in this respect is very much larger. All that the tests prove is that under some conditions about 300 milligrams of free $SO_2$ will kill yeast, and that combined $SO_2$ in much larger amounts than are ever used in practice has no permanent injurious effect on it.

The object of the foregoing tests was to determine the permanent effect of $SO_2$ on yeast which had been exposed to its action. As was shown, an exposure to about 300 milligrams per liter will kill yeast in twenty-four hours. This may be taken as a measure of its disinfectant power. Its antiseptic power measured by the amount in a nutritive solution which will prevent fermentation is much smaller. The ratio in antiseptic effectiveness between the free and combined is similar to that in disinfectant effectiveness as shown by the following tests.

Wine yeast was introduced into raisin must containing 2,000 milligrams per liter of total $SO_2$. Determinations of the free $SO_2$ were made at intervals and the time of the start of fermentation noted.

TABLE No. 17.

*Amount of free $SO_2$ which will permit fermentation to start.*

| Date. | Total $SO_2$ added milligrams per liter. | | Free $SO_2$ found milligrams per liter. | | Remarks. |
|---|---|---|---|---|---|
| | a | b | a | b | |
| January 1 | 2000 | 2000 | 246 | 246 | Added yeast. |
| January 10 | ---------- | ---------- | 83 | 83 | No fermentation. |
| January 17 | ---------- | ---------- | 66 | ---------- | No fermentation. |
| January 25 | ---------- | ---------- | 32 | 39 | A fermenting; B not fermenting. |

In this test the yeast did not become active until the amount of free $SO_2$ had fallen to between 30 and 40 milligrams per liter. This is probably not a maximum for wine yeast, as the long exposure to large quantities of free $SO_2$, which occurred at the beginning of this test, probably weakened the yeast and delayed its start.

To compare the antiseptic effect of combined $SO_2$ a parallel test was made. A series of flasks was filled with a raisin must which had been heated to a high temperature under pressure to cause rapid combination of the $SO_2$ added later. From 200 to 2,000 milligrams were added to the different flasks which were then inoculated with 1 per cent of a vigorous culture of wine yeast. All the flasks commenced to ferment within three days. This shows that 2,000 milligrams per liter of $SO_2$ will not prevent fermentation, if most of it is in the combined form and indicates an antiseptic ratio of over 60 to 1 in favor of the free.

2. EFFECT OF $SO_2$ ON THE MULTIPLICATION OF THE PRINCIPAL MICRO-ORGANISMS OCCURRING ON GRAPE. One of the chief uses of sulfurous acid in wine-making is to prevent the development and activity of injurious organisms entering the fermenting vats with the grapes or from other sources. Experiments were made to determine the relative susceptibility of the principal of these as compared with wine yeast.

Five series, each of 4 small flasks, were filled with normal grape must and to each flask of a series a different amount of $SO_2$ was added. Each series was then inoculated with a pure culture of a different organism and the number of active cells determined by means of plate cultures. Thirty-six hours later the number of active cells in each flask was determined again in the same way.

TABLE No. 18.

*Effect of $SO_2$ on multiplication of micro-organisms.**

| $SO_2$ milligrams per liter. | Wine yeast. | Apiculatus. | Wild yeast, Pastorianus form. | Penicillium. | Aspergillus. | Vinegar bacteria. |
|---|---|---|---|---|---|---|
| | Number of cells at start. | | | | | |
| | 20,000 | 150,000 | 620,000 | 120,000 | 450,000 | 310,000 |
| | Number of living cells after thirty-six hours. | | | | | |
| 0 | | | | | | 610,000 |
| 50 | 640,000 | 200,000 | 580,000 | 40,000 | 120,000 | 14,000 |
| 100 | 2,000,000 | 75,000 | 6,000 | 0 | 20,000 | 300 |
| 200 | 310,000 | 56,000 | 190 | 0 | 30,000 | 2 |
| 400 | 36,000 | 0 | 0 | 0 | 0 | 0 |

*All the organisms except the wine-yeast were isolated from California grapes.

This table shows very clearly the superior resistance of wine yeast. Fifty milligrams per liter diminished the number of molds and bacteria and allowed only a very small increase of apiculatus. The numbers of the last were decreased by 100 milligrams. The wine yeast increased rapidly with 50 and 100 milligrams and with slightly less rapidity with 200 milligrams. Even with 400 milligrams its increases were greater than that of apiculatus with only 50 milligrams.

These tests indicate that with the must used and under the conditions of the experiment, an addition of 100 milligrams per liter (equal to 26 ounces of metabisulfite to a thousand gallons) the development and activity of all the common injurious micro-organisms would be prevented and a practically pure yeast fermentation insured.

3. EFFECT OF $SO_2$ ON THE MIXTURE OF MICRO-ORGANISMS OCCURRING NATURALLY ON GRAPES. When grapes are brought to the winery, and are crushed, large numbers of molds and wild yeasts adhering to their surfaces get into the must. Some true wine yeast is usually present on ripe grapes but in smaller numbers. Experiments were

made to test the effect of small additions of $SO_2$ on such mixtures of micro-organisms. A must from somewhat moldy and damaged Palomino grapes was used, containing consequently a large number of active cells. The must was divided among a number of flasks to each of which a different small quantity of metabisulfite was added.

Before adding the $SO_2$, a count was made of the number of active cells present. Three hours after the addition, another count was made. Before taking the samples on which the counts were made, the flask was thoroughly agitated so that the count represents the total number of active cells present, none of them having been removed by settling.

TABLE No. 19.

*Modification of relative numbers of micro-organisms in natural must.*

| $SO_2$ added, milligrams per liter. | Time exposed. | Number of active cells per cubic centimeter. | | |
|---|---|---|---|---|
| | | Molds. | Apiculatus. | Yeast. |
| 0 | 0 | 97,625 | 7,341,400 | 58,575 |
| 30 | 3 hrs. | 13,310 | 189,930 | 182,995 |
| 75 | 3 | 19,360 | 21,780 | 33,880 |
| 120 | 3 | 14,650 | 14,650 | 43,950 |
| 180 | 3 | 7,600 | 0 | 58,400 |
| 240 | 3 | 4,800 | 0 | 73,600 |

This shows that the relative susceptibility of the molds, apiculatus and wine yeast are the same in mixtures as in pure cultures. The reduction in the proportions of active undesirable cells is very marked and very rapid even with small amounts. In the untreated must the apiculate yeast constituted 98 per cent of the total number of cells and the wine yeast less than 1 per cent. In three hours after the addition of 75 milligrams per liter (equal to 5 ounces of metabisulfite per ton) this proportion was changed to 28 per cent for the apiculate and 45 per cent for the wine yeast. With 180 milligrams per liter (equal to 12 ounces of metabisulfite per ton) the apiculatus was eliminated and the wine yeast constituted 88 per cent of the total. The small proportion of active mold spores left is negligible, as they usually have no effect on the fermenting wine.

A winery test of a similar nature gave similar results. Zinfandel grapes, which had been transported by rail, were crushed into a 2,200 gallon fermenting vat and sulfited at the rate of 8 ounces of potassium metabisulfite to the ton. A counting of the active cells was made before sulfiting and another an hour after the addition of $SO_2$. In the untreated must was found:

Molds ---------- 1,600,000 per cubic centimeter = 35.7 per cent.
Apiculatus ---------- 2,830,000 per cubic centimeter = 63.2 per cent.
Wild yeasts ---------- 30,000 per cubic centimeter = .7 per cent.
Wine yeast ---------- 20,000 per cubic centimeter = .4 per cent.

In the counting plates made after sulfiting only wine yeast was found and in increased numbers. All the other kinds had disappeared or failed to develop. This shows plainly the effectiveness of moderate doses of $SO_2$ in paralyzing injurious organisms. It is possible that some of the apiculatus and wild yeast might have recovered in time if afforded the opportunity, but if a starter of good yeast were used soon after sulfiting the fermentation would be over and the wine safe before they could develop.

4. EFFECT OF $SO_2$ IN DEFECATION. In making white wine, it is a common practice, after separating the must from the pomace by draining and pressing, to allow it to clear by settling and then to separate it from the sediment by drawing off into clean vats. This practice is known as "defecation," and is possible only when fermentation fails to start within about forty-eight hours. This delay of fermentation is usually insured by means of sulfuring or sulfiting.

Defecation removes most of the suspended inert matters such as fragments of the grape, and soil particles. It removes also a part of the living cells of micro-organisms. When sulfurous acid is used we obtain, in addition to this mechanical separation, the paralyzing effect already discussed. Tests were undertaken to determine the relative part of each of these factors in the results.

ELIMINATION OF INERT SOLIDS. Laboratory tests by R. W. Bettoli* demonstrated the difficulty of defecation by means of refrigeration except with musts of exceptionally clean and sound grapes which need it least. Certain molds and wild yeasts grow at very low temperatures and produce sufficient fermentation to prevent an adequate settling of impurities. Previous pasteurization is even less effective, at least with the musts used, on account of the increase in the viscosity of the liquid due to changes in the pectic matters which prevented settling.

Where $SO_2$ was used at the rate of 150 milligrams per liter the defecation was complete, the supernatant liquid being perfectly clear to the eye and containing no suspended matter which could be weighed after passing the clear must through a gooch filter. The original must tested by weighing a gooch filter through which it had been passed showed .554 per cent of suspended floating matter. This is sufficient to cause a bulky sediment in a wine made from undefecated must. The presence of so large a bulk of impurities during fermentation can hardly fail to have an injurious effect on the odor, taste and finer qualities of the wine.

These tests give us no measure of the extent to which elimination of the cells of micro-organisms is carried by defecation. Many of

*Loc. cit.

these cells will pass through an ordinary filter, and even if they were all retained their weight is too small for determination. Their elimination can be determined only by cultural and microscopical methods.

Bettoli* has shown that the number of active cells in a must can be reduced by defecation with from 100 milligrams to 300 milligrams of $SO_2$ per liter from 1,240,853 per c.c. to 255 per c.c. at 22° C. and to 1,500 per c.c. at 28° C. in forty-eight hours. The efficiency of the smallest amount of $SO_2$ was very little inferior in this respect to that of the larger. The lower efficiency at the higher temperature probably represents a slight mulplication of the cells which were not eliminated.

These results show the total reduction of active cells due both to settling and to the paralyzing effect of the $SO_2$. A measure of the part of each of these actors is given by comparison with determinations of the numbers of active cells in the sediments formed. In the sediments the average number of active cells was found to be 615 per c.c. at 22° C. and 7,747 per c.c. at 28° C. This indicates that the greater part of the cells were rendered inactive by means of the $SO_2$ and that only a relatively small number were removed by actual settling. The results are shown in more detail in Table 20.

TABLE No. 20.

*Elimination of micro-organisms by defecation.*

Number of active cells originally in must 1,240,853 per cubic centimeter.

| $SO_2$ used, milligrams per liter. | Temperature C. | Number of active cells per cubic centimeter. | | Elimination per cent. | |
|---|---|---|---|---|---|
| | | In sediment. | In clear juice. | Sediment. | Clear juice. |
| 100 | 22 | 1,005 | 45 | 99.91 | 99.99 |
| 150 | 22 | 645 | 630 | 99.94 | 99.94 |
| 200 | 22 | 585 | 315 | 99.95 | 99.97 |
| 300 | 22 | 225 | 30 | 99.98 | 99.99 |
| 100 | 28 | 16,857 | 3,810 | 98.64 | 99.69 |
| 150 | 28 | 5,055 | 180 | 99.59 | 99.98 |
| 200 | 28 | 6,045 | 1,695 | 99.51 | 99.86 |
| 300 | 28 | 3,030 | 345 | 99.75 | 99.97 |

This table shows that on the average 99.92 per cent of the active cells were eliminated from the clear must and 99.56 per cent from the sediment, leaving only .08 per cent in the former and .44 per cent in the latter capable of immediate development. The tests, however, do not show the nature of the cells which remain, a matter of importance.

ELIMINATION OF MOLDS AND WILD YEASTS. Laboratory experiments with apple juice showed that defecation with 100 milligrams of $SO_2$ per liter eliminated in twenty-four hours all active micro-organisms in

*Loc. cit.

both the clear juice and the sediment except the true yeasts. All the true yeasts were eliminated from the clear juice when 300 and 400 milligrams per liter were used. In the sediment active true yeasts were found in small numbers even when 400 milligrams per liter were used.

These tests indicate that the unfavorable activities of injurious organisms can be completely prevented by the use of $SO_2$ alone without defecation by settling. The utility of the settling is simply to remove the solid impurities which would depreciate the quality of the wine if they remained present during fermentation. Except perhaps with very inferior grapes, this result is of much less importance than the prevention of the activities of injurious organisms. Defecation by refrigeration is therefore much inferior in its effects to defecation by means of $SO_2$; in other words, the sulfiting of the must is of more importance than the clearing by settling. When sulfiting alone is used, after a delay of more or less extent, depending on how much $SO_2$ is used, the must will finally go through a practically pure fermentation; that is, the true, natural wine yeasts present will take exclusive possession of the must.

When the clear sulfited must, however, is drawn off the sediment before the start of fermentation there may be little or no yeast present. In this case the delay of fermentation may be very great or, worse still, it may be due to micro-organisms which get into the must after defecation and these micro-organisms are very likely in many cases not to be wine yeast principally. Whenever sulfiting and defecation are both practised, a starter, preferably of pure yeast, should be used immediately after removal of the must from the defecating vat.

Observations in the winery corroborate these results obtained in the laboratory. A must made from Green Hungarian grapes shipped from the San Joaquin Valley was defecated in a 1,500 gallon vat. The must was allowed to settle after adding metabisulfite at the rate of 6 ounces to 100 gallons. The number of molds, apiculatus and wine yeast cells was determined in the must before sulfiting and in the cleared must after settling thirty-two hours, with the results shown in Table 21.

TABLE No. 21.

*Elimination of micro-organisms in a 1500-gallon defecating vat.*

| | Molds. | Apiculatus. | Wine yeast. |
|---|---|---|---|
| Original must | 29,262 per c.c. | 6,603,028 per c.c. | 29,262 per c.c. |
| Defecated must | 256 per c.c. | 0 per c.c. | 492 per c.c. |
| Elimination | 91.3% | 100% | 83.2% |

A B

FIG. 5.

A, plate from undefecated must, showing molds; B, plate from defecated must, showing yeasts.

A similiar test was made with a Palomino must of the same origin. This must was defecated in the yeast apparatus with 4 ounces of metabisulfite to 100 gallons.

TABLE No. 22.

*Elimination of micro-organisms in small vat.*

| | Active cells per cubic centimeter. | | |
|---|---|---|---|
| | Molds. | Apiculatus. | Wine yeasts. |
| Original must | 112,658 | 1,565,658 | 529,133 |
| Defecated 8 hours | 44 | 660 | 13,800 |
| Defecated 20 hours | 10 | 0 | 16,280 |
| Elimination at 8 hours | 99.96% | 99.96% | 97.4% |
| Elimination at 20 hours | 99.99% | 100.00% | 97.0% |

These results show that comparatively small amounts of $SO_2$ very rapidly eliminated all the active cells except those of wine yeast. For the fullest effect, desirable in the preparation of starters, defecation should continue for at least twenty-four hours. This will insure the absence of all active injurious organisms. There will probably be a slight admixture of the natural wine yeasts of the grape when selected pure yeasts are used, but this contamination is in practice perfectly harmless and experience with the use of selected pure yeasts in wineries shows that with ordinary precautions it is reduced to very little.

5. CHANGES IN THE SUSCEPTIBILITY OF WINE YEAST TO $SO_2$. In 1905 a series of experiments was made to test the alleged possibility of training a yeast to withstand increased amounts of $SO_2$. A must of 20 per cent Balling and .7 per cent acidity was divided among six flasks, to each of which was given a different dose of $SO_2$. They were then all inoculated with a pure culture of wine yeast. The flask containing the least $SO_2$ commenced to ferment first. As soon as this occurred, the flask containing the next higher amount was inoculated with yeast from the fermenting flask and so on until the end of the series. The results are shown in the following table:

TABLE No. 23.

*Exposure of yeast to increasing doses of $SO_2$.*

| Flask. | $SO_2$ added, milligrams per liter. | Remarks. |
|---|---|---|
| (*a*) | 60 | *April 16, all flasks inoculated.* |
| (*b*) | 100 | *April 19, (a) fermenting, inoculated (b) from (a).* |
| (*c*) | 200 | *April 20, (b) fermenting, inoculated (c) from (b).* |
| (*d*) | 350 | *April 21, (c) fermenting, inoculated (d) from (c).* |
| (*e*) | 550 | *April 23, (d) fermenting, inoculated (e) from (d).* |
| (*f*) | 1000 | *May 1, (e) fermenting, inoculated (f) from (e).* |
| | | *May 8, (d) fermenting.* |
| | | *May 15. All flasks fermented dry.* |

Observations of this kind have been interpreted as showing an increased resistance of yeast to $SO_2$ when gradually accustomed to its presence. The yeast, for example, in flask *f* receiving 1,000 milligrams of $SO_2$ per liter had not caused fermentation at the end of fifteen days. When yeast which was causing fermentation in flask *e* to which had been added 550 milligrams of $SO_2$ was placed in flask *f* fermentation started in seven days.

The correct interpretation of these facts has been shown by later tests to be this: The yeast placed in flask *f* immediately after the addition of 1,000 milligrams of $SO_2$ was killed or weakened because a large part of the $SO_2$ was in the free form. Fifteen days later, when the second inoculation of yeast was made, most of the $SO_2$ had changed to the combined form and insufficient free $SO_2$ existed to prevent fermentation. The start of fermentation, therefore, was not due to a greater resistance of the yeast, but to decrease of the antiseptic properties of the $SO_2$.

Other experiments made at the same time pointed to an actual weakening of the yeast by exposure to $SO_2$. To investigate this point, a series of tests was made in 1911. Three series of nine flasks each were filled with grape must. Each flask of a series received a different

amount of $SO_2$, the corresponding flasks of each series receiving the same amount. After sulfiting, each flask was inoculated with 1 per cent of the same vigorous pure yeast, unaccustomed to sulfurous acid.

Series III consisting of flasks *a''* to *i''* was left without further treatment until the end of the experiment. Series II consisting of flask *a'* to *i'* and Series I consisting of flasks *a* to *i* were left for five days until it was apparent that fermentation had started in all the flasks where it was possible without new inoculation. In twenty-four hours the first five flasks of all series had commenced to ferment. At the end of five days none of the last three had commenced. In Series II, flask *g'* was then inoculated with yeast from flask *f'* of the same series, accustomed to $SO_2$. In Series I flask *g* was inoculated afresh with the yeast unaccustomed to $SO_2$. This process was continued until all the flasks of Series I and II had fermented. Each flask of Series II was inoculated with yeast from the flask immediately below it, while at the same time the corresponding flask of Series I was inoculated with the original yeast unaccustomed to $SO_2$. The same variety of yeast was used in all cases.

TABLE No. 24.

*Comparison of accustomed with unaccustomed yeast.*

| Series I. | Series II. | Series III. | $SO_2$, milligrams per liter. |
|---|---|---|---|
| *a* | *a'* | *a''* | 200 |
| *b* | *b'* | *b''* | 250 |
| *c* | *c'* | *c''* | 300 |
| *d* | *d'* | *d''* | 350 |
| *e* | *e'* | *e''* | 400 |
| *f* | *f'* | *f''* | 500 |
| *g* | *g'* | *g''* | 600 |
| *h* | *h'* | *h''* | 800 |
| *i* | *i'* | *i''* | 1000 |

| | |
|---|---|
| July 31, 6 p. m. | Inoculated all flasks and placed at 29° C. |
| August 1, 8 a. m. | All flasks from beginning to *f*, *f'*, and *f''* fermenting. |
| August 5, 5 p. m. | No flask started above the *f* row in any series. |
| | Inoculated *g* with unaccustomed yeast. |
| | Inoculated *g'* with yeast from flask *f'*. |
| August 7, 8 a. m. | *g* fermenting; *g'* and *g''* not started. |
| August 8, 8 a. m. | *g* fermenting vigorously; *g'* just starting; *g''* not started. |
| August 10, 8 a. m. | *g* and *g'* fermenting vigorously. |
| August 16, 8 a. m. | Inoculated *h* with unaccustomed yeast. |
| August 16, 8 a. m. | Inoculated *h'* with yeast from *g'*. |
| August 21, 8 a. m. | *h* and *h'* fermenting vigorously; *g''* not started. |
| | Inoculated *i* with unaccustomed yeast. |
| | Inoculated *i'* with yeast from *h'*. |
| August 22, 8 a. m. | *i* fermenting; *i''* not started; *i'* not started. |
| August 23, 8 a. m. | *i* fermenting vigorously; *i'* just starting. |
| | *g''*, *h''* and *k''* not started. |

This experiment shows conclusively that exposure to $SO_2$ does not increase the resistance of yeast, but on the contrary makes it more susceptible. This is shown by the fact that flask *g* inoculated with yeast unaccustomed to $SO_2$ fermented in fifteen hours, while the corresponding flask *g'* containing the same amount of $SO_2$ and inoculated with a yeast accustomed to $SO_2$ did not start to ferment until after thirty-seven hours; and flask *i* inoculated with unaccustomed yeast started to ferment in twenty-four hours, while *i'* with accustomed yeast required forty-eight hours.

None of the last three flasks of Series III started at all, though the free $SO_2$ must have fallen as low as in the corresponding members of the other series where fermentation took place. This indicates that the yeast was killed or much weakened by the amount of $SO_2$ placed in these flasks.

Another series of experiments was made in the attempt to make a quantitative determination of the effect on yeast of prolonged contact with $SO_2$.

A flask B containing 100 c.c. of must, to which 100 milligrams of $SO_2$ had been added was inoculated with 1 per cent of a culture of Burgundy yeast. A similar flask A without $SO_2$ was inoculated with the same yeast. Both were incubated at 32° C. When both were in full fermentation, a flask of must containing 100 milligrams of $SO_2$ per liter was inoculated with the yeast from flask B grown in the presence of 100 milligrams $SO_2$ and a similar flask was inoculated with yeast from flask A grown in must free from $SO_2$. The progress of the fermentation was then determined by periodical weighing of the flasks as shown in Table 25. The same procedure was followed in Series II and III using 200 and 300 milligrams of $SO_2$ per liter, respectively, both for the previous training of the yeast and for the fermentations.

TABLE No. 25.

*Increase of susceptibility of yeast by exposure to $SO_2$.*

Series I. 100 milligrams $SO_2$ per liter. Experiment 372a. Weight in grains.

| Hours. | Flask A, untrained yeast. | Flask B, trained yeast. | A—Loss in weight. | B—Loss in weight. |
|---|---|---|---|---|
| 0 | 304.50 | 307.69 | 0 | 0 |
| 23 | 303.89 | 307.10 | .6 | .59 |
| 52 | 301.57 | 304.64 | 2.93 | 3.05 |
| 70 | 299.85 | 302.80 | 4.65 | 4.89 |
| 92 | 297.05 | 300.07 | 7.45 | 7.62 |
| 119 | 295.30 | 298.50 | 9.20 | 9.19 |
| 138 | 294.54 | 297.79 | 9.96 | 9.90 |
| 168 | 294.45 | 297.65 | 10.05 | 10.04 |
| Series II. 200 milligrams per liter. Experiment 372b. | | | | |
| 0 | 321.05 | 313.25 | 0 | 0 |
| 17 | 320.07 | 313.10 | .18 | .15 |
| 51 | 319.10 | 312.05 | 1.95 | 1.20 |
| 78 | 315.77 | 309.80 | 5.28 | 3.45 |
| 97 | 315.24 | 308.47 | 5.81 | 4.78 |
| 127 | 313.05 | 306.25 | 8.00 | 7.00 |
| 150 | 311.81 | 304.75 | 9.24 | 8.50 |
| 173 | 311.10 | 303.67 | 9.95 | 9.58 |
| 193 | 310.75 | 303.02 | 10.30 | 10.25 |
| 211 | 310.42 | 302.57 | 10.63 | 10.68 |
| 235 | 310.20 | 302.27 | 10.85 | 10.88 |
| Series III. 300 milligrams per liter. Experiment 372c. | | | | |
| 0 | 288.35 | 287.92 | 0 | 0 |
| 22 | 287.83 | 287.72 | .52 | .2 |
| 45 | 286.72 | 286.82 | 1.63 | 1.1 |
| 65 | 284.55 | 284.82 | 3.80 | 3.1 |
| 83 | 282.50 | 282.72 | 5.85 | 5.20 |
| 107 | 280.47 | 280.82 | 7.88 | 7.10 |
| 141 | 278.31 | 278.92 | 10.04 | 9.00 |
| 165 | 277.59 | 277.85 | 10.76 | 10.07 |
| 182 | 277.19 | 277.35 | 11.16 | 10.57 |
| 227 | 276.55 | 276.67 | 11.80 | 11.25 |

In the flasks containing 100 milligrams per liter, the fermentations follow almost exactly the same course, showing no effect from the previous exposure to $SO_2$. In the flasks containing 200 milligrams the fermentation in the flask inoculated with "trained" yeast is slower at first but catches up by a more rapid fermentation near the end. In the flask containing 300 milligrams the fermentation of the "trained" yeast is uniformly slower from beginning to end.

Both yeasts caused a slower fermentation in the presence of 200 and 300 milligrams of $SO_2$ than in that of 100 milligrams.

With regard to the rate of fermentation, therefore, we have two effects due to $SO_2$, both tending to retard it. The fermentation is slower in musts containing the larger quantities of $SO_2$, owing to the immediate effects of the $SO_2$ in decreasing the activity of the yeast. This decrease of activity, moreover, persists, so that a yeast which has developed in the presence of $SO_2$ is less active than before exposure when placed in musts containing large doses of $SO_2$. These effects are shown in diagram 6.

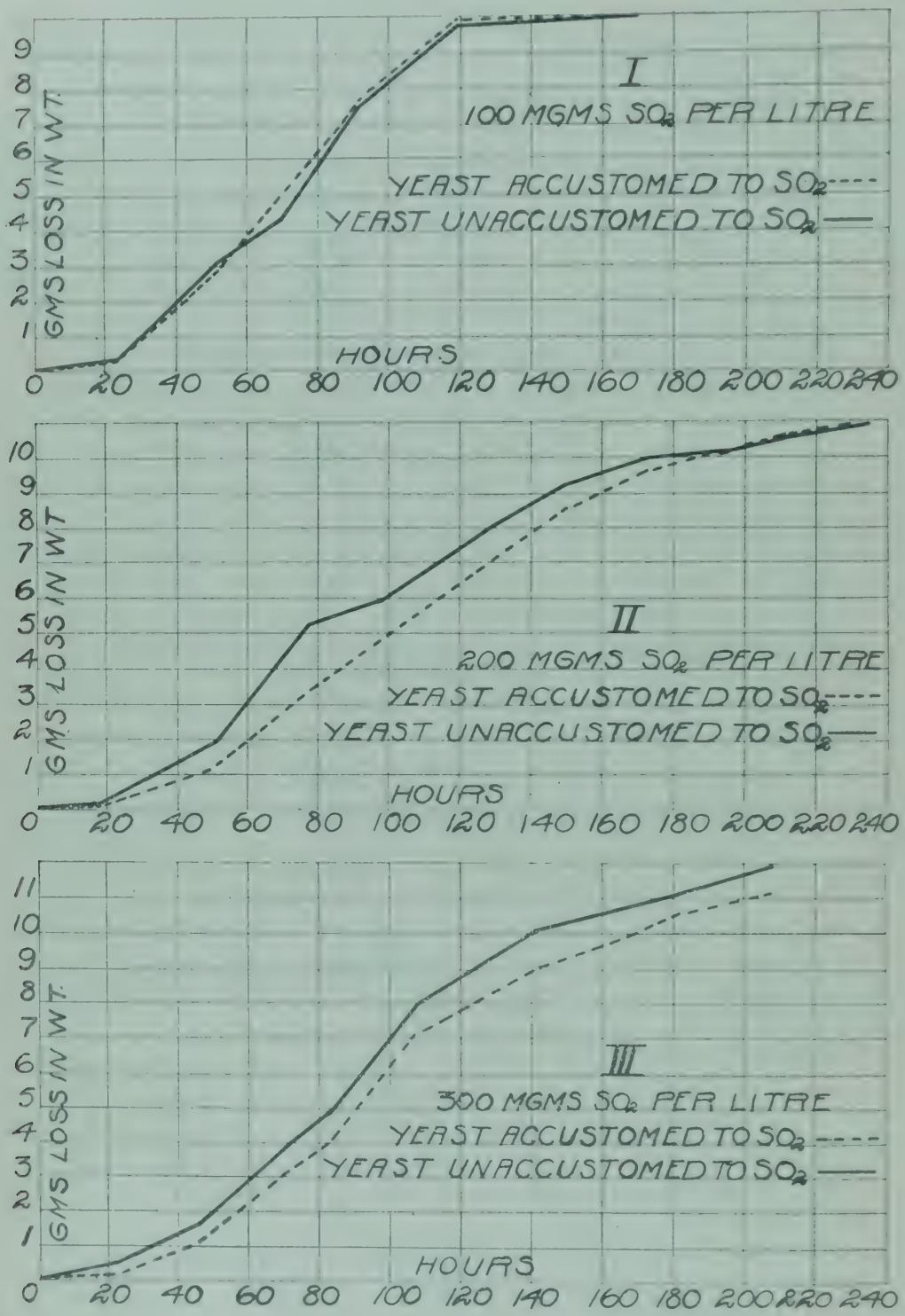

GMS LOSS IN WT.
HOURS
0 20 40 60 80 100 120 140 160 180 200 220 240
I
100 MGMS $SO_2$ PER LITRE
YEAST ACCUSTOMED TO $SO_2$ ----
YEAST UNACCUSTOMED TO $SO_2$ ——
II
200 MGMS $SO_2$ PER LITRE
YEAST ACCUSTOMED TO $SO_2$ ----
YEAST UNACCUSTOMED TO $SO_2$ ——
III
300 MGMS $SO_2$ PER LITRE
YEAST ACCUSTOMED TO $SO_2$ ----
YEAST UNACCUSTOMED TO $SO_2$ ——

DIAGRAM 6.

Comparison of fermentative activity of "trained" and "untrained" yeast.

The theory that yeast can be gradually "trained" to withstand increasing doses of $SO_2$ is incorrect under the conditions covered by these tests. On the contrary, its susceptibility, as evidenced by the rate of fermentation, is increased.

This decrease in rapidity may be an advantage in aiding cool fermentation for as indicated by these tests it is principally at the start. In practice it is found, however, that little aid is to be obtained in this way in avoiding hot fermentations. The lesson to be drawn from these tests is that pure yeast and starters should be grown in the presence of comparatively small amounts of $SO_2$, in order to maintain the vigor and power of rapid multiplication necessary to permit them rapidly to outnumber all other micro-organisms occurring in the must.

Tests made with yeast from a cellar yeast-apparatus gave similar results. Must showing 25° Balling was placed in two series of flasks. Series A consisted of flasks *a, b, c, d* and *e,* which received 100, 150, 200, 300 and 500 milligrams of $SO_2$ per liter, respectively. Series B consisted of five flasks $a_2$ to $e_2$ sulfited in the same way. Series A was inoculated immediately with a vigorous yeast grown in must without $SO_2$. Series B was inoculated at the same time with the same variety of yeast which had been grown for a month in the yeast apparatus in must sulfited to the extent of 200 milligrams per liter. The yeast in the apparatus was pure and apparently vigorous. Moreover, it had given excellent results in fermenting wine on a practical scale. The course of fermentation in the various flasks was observed by daily readings of the Balling per cent.

Of the flasks inoculated with "untrained" yeast, 3 fermented, but only one of the flasks receiving "trained" yeast. The course of the fermentation is shown in Table 26.

TABLE No. 26.

*Weakening of yeast by exposure to $SO_2$.*

| Hours. | A—Unaccustomed yeast. Balling per cent. | | | B—Accustomed yeast. Balling per cent. |
|---|---|---|---|---|
| | a 100 milligrams. | b 150 milligrams. | c 200 milligrams. | $a_2$ 100 milligrams. |
| 0 | ---------- | 25.25 | 25.25 | 25.25 |
| 96 | 25.25 | 25.25 | 25.25 | 25.25 |
| 120 | 25.00 | 25.25 | 25.25 | 25.00 |
| 145 | 24.00 | 25.25 | 25.25 | 25.25 |
| 168 | 18.00 | 24.00 | 25.00 | 16.00 |
| 193 | 13.50 | 20.00 | 21.00 | 11.50 |
| 221 | 6.00 | 10.50 | 14.00 | 5.00 |
| 240 | 3.50 | 7.00 | 8.50 | 2.50 |
| 268 | .50 | 4.00 | 5.00 | 0 |
| 292 | 0 | .5 | 1.0 | 0 |
| 315 | 0 | 0 | 0 | 0 |

Here, as in the former series of experiments the accustomed and the unaccustomed yeasts gave almost identical results in the must containing only 100 milligrams $SO_2$ per liter. Where larger amounts were used, however, the accustomed yeast showed an increase of susceptibility by failing to grow in musts containing 150 and 200 milligrams per liter in which the unaccustomed yeast grew readily.

In these experiments the yeast was added soon after the addition of the sulfite while a large amount of the $SO_2$ still existed in the free state. In practice, the addition of yeast should be deferred for at least twelve hours after sulfiting, especially where more than 100 milligrams per liter of $SO_2$ is employed. If this precaution is taken, there need be no fear that the yeast will lack vigor if it has been grown in the presence of only moderate amounts of $SO_2$.

## III. UTILITY AND METHODS OF APPLICATION OF PURE YEAST IN WINE-MAKING.

(a) *Present Status of Pure Yeast in Wine-making in California.* In 1893 the station commenced to investigate the possibility of improving our wines by the use of pure and selected yeast. The first tests with a Johannisberg wine-yeast from Geisenheim on the Rhine were made on a small scale at the station cellar. The results were promising and in 1895 a number of pure yeasts from the Rhine, Médoc, Burgundy, Sauternes, Italy and Algeria were tested at the station and distributed to wine-makers in various parts of the state for trial.

The conclusions drawn from the small station tests were that the use of pure yeast promoted a quicker fermentation, a more prompt clarification and produced a wine of cleaner taste and with some improvement in bouquet and flavor. The tests at wineries were less favorable. In many cases, where the pure yeasts were used, the wines failed to ferment to dryness, while the naturally fermented wines became quite dry. This was especially marked in the case of the German yeast which produced a dry wine only in one case. The successful fermentation was that of a light Burger must and the resulting wine was much superior to the witness. The cause of the failures of this yeast was its unsuitability to our heavy musts. The failure of the other yeasts seems to have been due to the fact that the addition of yeast promoted a rapid development of the fermentation, and a rise of temperature to a point that paralyzed the yeast before the sugar had all been eliminated.

These results showed that a proper selection of yeast was necessary and that the use of pure yeast without some means of controlling the temperature of fermentation was liable to do more harm than good.

Since 1895 the work of testing pure yeast and the methods of application have been continued. Many yeasts from most of the chief wine-producing regions have been imported and tested in comparison with yeasts isolated from Californian grapes and wines. The results have shown that before using pure yeast some means of controlling the injurious yeasts, molds and bacteria must be adopted. This means has been found in the proper use of sulfurous acid. With this help the improvements obtained in the small scale station tests can be realized in practice. All the yeasts tested, both imported and native, have given good results with the exception of some German yeasts which were unsuited to heavy musts. On the whole, the yeasts obtained from the Champagne and Burgundy districts have been found the most suitable and have given the greatest improvement in increase of quality and in simplifying the handling of the wine. For this reason we have limited our supply of yeast to wineries to two or three forms originating in these districts, and they have given satisfactory results in all kinds of wine.

Whether other yeasts will give better results in special cases can be determined only with time and the multiplication of experiments. The improvement obtained by the use of these yeasts is so much greater than any differences existing between different pure yeasts, that it seems safer to use them exclusively in our large scale tests until the methods and advantages of the use of pure yeast are better understood by most cellar-men.

(*b*) *Organisms found on Californian Grapes.* As pointed out in Bulletin 213, the spores of any organism carried by the wind may be found on the surfaces of grapes as they come to the winery. Many of these organisms are incapable of growing on grapes or in must or wine. A large number, however, are capable of growing on the grapes when the conditions are favorable and many will grow in the must and some in the wine itself. They are all useless with the exception of the wine yeast and many of them highly injurious in wine-making. The principal injurious forms have been described in Bulletin 213. Some of the most troublesome often occur in abundance and always in much larger numbers than the necessary wine yeast. In fact, the latter is often present in such small numbers that it cannot be found by ordinary methods.

The possibility of restraining the activities of these troublesome organisms in wine-making by the use of $SO_2$ has already been discussed. Its necessity is made evident by investigations, made during the past season, on the kinds and numbers of micro-organisms occurring naturally on Californian grapes as they hang in the vineyard

and as they arrive at the cellar after gathering, hauling and shipping. The results emphasize the need of the use of $SO_2$ and the utility of the employment of selected yeast.

1. Davis. On a sample of Muscat grapes gathered in the vineyard of the University Farm at Davis were found in large numbers, 3 molds, 3 wild yeasts, and, in small numbers, 2 wine yeasts.

TABLE No. 27.

*Micro-organisms* found on grapes at Davis.*

1. Green mold (*Penicillium* sp.).
2. Gray mold (*Mucor* sp.).
3. Black mold (*Aspergillus* sp.).
4. Apiculate yeast (*Saccharomyces apiculatus*).
5. Film-forming wild yeast (*Saccharomyces* sp.).
6. Sediment wild yeast (*Saccharomyces* sp.),
7. Wine yeast (2 forms) (*Saccharomyces ellipsoideus*).

This is typical of what may be found on any ripe grapes in any vineyard in California or, in fact, in any region. If the grapes are gathered carefully while sound, hauled to the winery promptly and properly handled by the wine maker, the three molds would do no harm. If the grapes are injured by insects, diseases, rough handling or rain, if they are kept for a day or two before being crushed, these molds would very much depreciate their value and even spoil the wine made from them.

The apiculate and other wild yeasts may render the wine inferior by developing in the fermentation vats and casks unless $SO_2$ is properly used. The wine yeasts from such grapes as these will sometimes not develop at all or not until after the others have increased sufficiently to seriously injure the quality of the wine. This is what often occurs with the first grapes of the season. As the season advances, the wine yeast gradually increases in the grape boxes, crushers and conveyers so that when $SO_2$ is used to restrain the injurious yeasts, the natural wine yeasts ultimately prevail. This method of obtaining our wine yeast from dirty crushers is, however, uncertain and illogical. With grapes from some localities, it usually gives us finally a sufficiently good yeast, with others it is more uncertain. In all cases the kind of wine yeast we finally obtain is liable to vary from year to year, and it is much better practice to start at the beginning of the vintage with a pure culture of a suitable and tested yeast.

The apiculate yeast found on the Davis grapes was tested and produced a slow fermentation, which at the end of three weeks had pro-

* These observations refer only to such micro-organisms as were present in notable numbers, *i. e.*, usually hundreds or thousands in every drop of must and which grew readily in must.

duced only .3 per cent of alcohol. To do this, it destroyed 2.1 per cent of sugar, from which a wine yeast would have produced over 1 per cent of alcohol. The must, after fermentation, had a fruity odor, and cleared very slowly. It thus showed two of the chief defects of apiculatus fermentation, viz., waste of sugar and persistent cloudiness of the wine.

The film-forming yeast gave a heavy surface growth and very little fermentation. The liquid acquired a disgusting odor and taste and lost 4.3 per cent of sugar with the production of only .3 per cent of alcohol.

The second variety of wild yeast made a heavy sediment growth and caused a short and feeble fermentation. It gave the must at first a fruity odor and after several weeks a decidedly rancid odor and taste, due probably to the formation of butyric acid. It produced only 2 per cent of alcohol.

The two varieties of wine yeast gave a vigorous fermentation, fermenting to dryness a must showing 28 per cent Balling. They were of similar appearance under the microscope, but one gave a very fine-grained pasty sediment, while the sediment of the other was flocculent and more bulky. They were isolated only at the end of the spontaneous fermentation of the must and were not found on the fresh grapes, showing that they were present in much smaller numbers than the injurious forms.

2. CONTRA COSTA COUNTY. The principal micro-organisms of grapes grown and crushed in Contra Costa County were isolated from the must as it came from the crusher. The following forms were found:

TABLE No. 28.

*Micro-organisms found in must of Contra Costa County grapes.*

1. Green mold (*Penicillium* sp.)
2. Gray mold (*Mucor* sp.)
3. Black mold (*Aspergillus* sp.)
4. Apiculate yeast (*Saccharomyces apiculatus*).
5. Wild yeast growing rapidly in must, forming a thick leathery film but causing little fermentation.
6. Wild yeast with large oblong cells forming a thin film, thick sediment and causing little fermentation.
7. Wine yeast forming a fine-grained pasty sediment and causing a good fermentation.

3. Acampo. Grapes grown at Acampo and shipped to Martinez showed a similar choice selection of forms:

TABLE No. 29.

*Micro-organisms found in must of grapes from Acampo.*

1. Green mold (*Penicillium* sp.).
2. Gray mold (*Mucor* sp.).
3. Gray mold (*Botrytis* sp.).
4. Black mold (*Aspergillus* sp.).
5. Apiculate yeast (*Saccharomyces apiculatus*).
6. Wild yeast—Spherical, film-forming
7. Wild yeast—Large, oblong, film-forming } (*Saccharomyces* sp.).
8. Wild yeast—Elongated, film-forming
9. Wine yeast—Small, ellipsoidal (*Saccharomyces ellipsoideus*).
10. Wine yeast—Spherical (*Saccharomyces ellipsoideus*).

Some of the musts examined were extracted from clean, sound grapes, others from grapes in a more or less broken or moldy condition. Practically, the same kinds of organisms were found in all, and in all cases the wine yeasts were in a very insignificant minority. The condition of the grapes made little difference in the relative number of wine yeast cells present, but influenced considerably the total number of all kinds.

To give a quantitative idea of the relative number of the various forms in various musts, counts were made in the must as it came from the crusher. The method used was to count the number of colonies, which developed from a measured quantity of must in plates of gelatin must.

TABLE No. 30.

*Number of micro-organisms in various musts.*

Number of active cells in 1 cubic centimeter.

| Must. | No. 198. | No. 199. | No. 194. | No. 261. | No. 202. |
|---|---|---|---|---|---|
| Molds | 59,000 | 1,300 | 29,000 | 98,000 | 1,600,000 |
| Wild yeasts (plus apiculatus) | 28,000 | 1,267,000 | 8,603,000 | 7,341,000 | 2,880,000 |
| Wine yeasts | 0 | 0 | 29,000 | 59,000 | 20,000 |

No. 198 was Zinfandel grown in the neighborhood and crushed in good condition. It shows the smallest total number of active cells. All that developed, however, were injurious molds and wild yeasts. This does not mean necessarily that no true wine yeast was present. It simply means that, if there, it was in such small amounts that the methods used failed to reveal its presence.

No. 199 was Alicante Bouschet grown at Acampo and shipped to Martinez. When crushed they were in fairly good condition. The number of mold cells was very small, but that of the wild yeasts high:

owing probably to development and multiplication on broken berries in transit. The wine yeast was again insufficiently numerous to be found.

No. 194 was Green Hungarian grown in San Joaquin County and shipped to Martinez. The grapes were not in such good condition as the Bouschets. Being tender and juicy they suffered more in shipment. Wine yeast was found in this must in moderate numbers, but the wild yeasts were in such large numbers that the ratio between them was probably little different from that in No. 198.

No. 202 was second crop Zinfandel in very moldy condition.

No. 261 was Palomino must from grapes that arrived in very poor condition.

These observations show the necessity of crushing the grapes as soon as possible after gathering to prevent the growth of injurious molds. The practice of shipping grapes in boxes or loose in cars is objectionable as it gives the molds an opportunity to develop and depreciate the value of the grapes before they reach the winery. A much better practice is to crush the grapes at or near the vineyard into tank cars in which they are transported to the winery.

They show also the need of using sulfurous acid as soon as the grapes are crushed in order to prevent the development of the apiculate and other injurious yeasts which are always present. Grapes which are crushed and sulfited at the vineyard may be transported in tank cars in perfect condition to the winery even though they are two or three days on the way.

The need of using a starter of good yeast is also strongly indicated. This starter should be added at least several hours after the sulfiting. When sulfited grapes are shipped the yeast should be added as soon as the grapes are placed in the fermentation vats in the winery.

(*c*) *Methods of Transmitting Pure Yeasts.* The station has been supplying yeast cultures to wine-makers for many years and their utility has been thoroughly demonstrated. It is very important, however, that only a suitable yeast should be used. Some of the yeasts, sent out at first, were unsuited to Californian musts and conditions. As a rule, yeast is needed which is able to ferment musts of high sugar contents and which can withstand high temperatures. Certain German wine-yeasts tried failed in this respect. Many yeasts have given good results, but the most generally successful are those of Champagne and Burgundy type. These yeasts are thoroughly suited to our musts, and moreover have the excellent property of forming a heavy granular sediment which settles rapidly and leaves the wine bright very shortly after fermentation.

Occasionally yeasts sent to wineries have failed to develop. This is due to the fact that they soon lose activity in the liquid form in which

we have sent them and, unless used within a week from the time at which we prepare them, they are difficult to revive by the methods available to the wine-maker.

Such yeasts are not permanently injured and when revived by suitable means regain all their qualities. By transferring to fresh sterilized must and aerating thoroughly, they may in a few days be rendered active again. If placed in sterilized must without aeration, they may not develop at all. If put directly into fresh unsterilized must they may develop so slowly as to be overwhelmed by the wild yeasts present.

When yeasts are sent out to the winery to be used directly in fermenting vats as they are received they should not be more than a few days old when used. When used first to start a yeast-propagating apparatus, they may be used safely when they are several weeks old, providing proper precautions are taken to avoid contamination with other micro-organisms before they have regained their full activity. It has been shown that yeast grown on a solid culture medium retains its vigor much longer than when grown in a liquid medium. This is usually ascribed to the fuller aeration which the yeast receives when growing on the surface of a solid medium than when growing submerged in a liquid. It is well known that growing yeast with a full supply of air will increase its vigor, but the retention of this vigor is in this case more probably due to the fact that when growing on the surface of its nutrient medium it is protected to some extent from contact with its own products such as alcohol. Another factor is possibly that owing to the fixed position of the yeast and the solid condition of the medium, both the multiplication of the yeast and the exhaustion of the food supply are retarded.

Tests were made to compare the retention of vigor by yeast grown in each way. A series of tubes containing grape must was inoculated, half with yeast C and half with yeast B. A similar series containing solid agar must was inoculated, while warm enough to be fluid, in the same way. While the tubes of agar must were cooling they were rolled so that the solid nutrient material was spread in a thin layer over the inner surfaces of the tube. At intervals after inoculation, the contents of a tube of each lot were transferred to a flask of sterile must and, two days after this transfer, the number of living cells in the flask was counted. The numbers thus obtained give a measure of the number of living cells in the original tube at the time of the transfer, and of the rapidity with which they multiplied in the fresh must.

TABLE No. 31.

*Relative stability of liquid and solid yeast cultures.*

| Age of culture in tubes. | Yeast C. Cells per cubic centimeter. | | Yeast B. Cells per cubic centimeter. | |
|---|---|---|---|---|
| | Liquid culture. | Solid culture. | Liquid culture. | Solid culture. |
| 1 day | 105,000,000 | 40,000,000 | 170,000,000 | 80,000,000 |
| 2 days | 65,000,000 | 85,000,000 | 105,000,000 | 105,000,000 |
| 3 days | 92,000,000 | 95,000,000 | 100,000,000 | 125,000,000 |
| 4 days | 45,000,000 | 65,000,000 | 93,000,000 | 110,000,000 |
| 16 days | 50,000,000 | 25,000,000 | 28,000,000 | 71,000,000 |
| 32 days | 4,000,000 | 13,000,000 | 7,500,000 | 43,000,000 |

These results indicate that during the first twenty-four hours the yeast is more efficient if grown in liquid medium. For a week or perhaps two there is little difference, but, at the end of a month, the advantage is very plainly with the yeast on solid culture medium.

Utilizing this property of solid cultures, a company in France prepares a form of yeast for wineries under the proprietary name of "Gelolevures." The yeast is grown on a thin layer of nutrient gelatine spread on a piece of thin cloth. Several of these pieces are suspended on a support inside a sealed tin case. The directions accompanying these tins are to remove the stopper, fill with sterilized must and place in a warm place. As soon as fermentation commences, the cover is removed and the whole contents of the tin are poured into a fermenting vat just filled with grapes. Tins of various sizes are supplied for vats of various capacities. The claim made for these yeasts is that they retain their vigor indefinitely and obviate the necessity of preparing a starter.

Sample tins of "Gelolevures" were received at the station for examination. To test their vigor, one of the tins, three months old, was treated according to the directions. At the same time a large flask, containing a liquid culture of yeast two months old, was used for comparison. The liquid in the latter was poured off the yeast sediment and the flask filled with the same must used to fill the tin of "Gelolevures." The must in the tin started to ferment sooner than that in the flask and finished fermenting in a shorter time.

The promptness with which the fermentation started in the "Gelolevures" demonstrated the superiority of this method of preparing yeast where it is to be used directly in the vats without the intermediate preparation of a starter, and where there is any considerable interval between the preparation of the yeast and its use.

A similar test was made with yeasts prepared in the laboratory. Two small flasks, in which a Champagne yeast was grown on a solid medium, were kept in the laboratory for five months. At the end of

that time, sterile must was added to the flasks, and was in full fermentation within twenty hours. Liquid cultures of the same yeast kept for the same length of time require careful manipulation to revive them. The reviving of a weak culture cannot safely be undertaken at the winery, owing to the great chance of contamination from outside organisms. A strong, solid culture, on the other hand, such as those contained in these flasks or the "Gelolevures," could easily be used to make a starter by ordinary methods easily employed by a competent wine-maker.

These tests all indicate the superiority of solid cultures for transmitting yeast for use in wineries, and most of the cultures sent out by the station during the last vintage were in this form.

(*d*) *Methods of Use in Wineries.* 1. DIRECT APPLICATION. There are two general methods of using pure yeast in wineries. The simplest in theory is to obtain from a reliable pure yeast laboratory a culture of yeast for each vat of grapes or cask of must to be fermented. This method, however, is expensive, involving the buying and transportation of large quantities of yeast.

It has been found, empirically, that it requires about 1 per cent of yeast to properly start a vat of sulfited grapes or defecated must. This means that ten gallons of a vigorous culture of yeast should be added to 1,000 gallons of must to ensure that the fermentation is due principally to the yeast added.

Determinations of the numbers of cells present in yeast cultures, and in sulfited musts at the winery indicate that these proportions are suitable. An average vigorous culture of wine-yeast in grape must will contain about 200,000,000 active cells per cubic centimeter. A properly sulfited must will contain no injurious wild yeast, and the natural wine yeast will be reduced to a few tens of thousands per cubic centimeter, even in musts made from grapes in bad condition. A 1 per cent addition of a vigorous culture of pure yeast would introduce approximately 2,000,000 cells per cubic centimeter into the whole mass. The pure yeast cells, therefore, would be, even in unfavorable cases, a hundred times more numerous than the natural yeast cells, while, in ordinary musts made from clean grapes, promptly crushed and sulfited, a 1 per cent addition of pure yeast would cause the added yeast to outnumber the natural yeasts many thousand times, and insure a fermentation which would be practically pure so far as contamination with other yeasts is concerned.

A smaller addition than 1 per cent, however, is not found advisable in practice, except in very hot weather, when it may be reduced a little. If too little is used, the start of fermentation is unduly prolonged, and

more than seems theoretically necessary must be used as a safety factor to provide against possible unusual contamination of the grapes or lack of vigor of the culture.

To start the fermentation of a vat, containing 1,000 gallons of crushed grapes by adding a liquid yeast culture directly, would require 10 gallons, which, with the glass containers, would weigh approximately 150 pounds. If solid cultures were used, prepared in glass flasks or bottles, such as were sent out by the station during the last vintage, the weight could be reduced to about 50 pounds. The tin cases of the "Gelolevures" make it possible to still further reduce this weight to about 15 pounds. Even the last weight is considerable, and the amount of yeast necessary makes the method very expensive.

2. PREPARATION OF A STARTER. Several years of experience have thoroughly demonstrated that it is perfectly practicable for any intelligent cellar-man to commence with a small culture of pure yeast, and prepare his own yeast from this in the form of a starter in any quantity needed.

The method is perfectly simple and equally adapted to large or small cellars. Expensive equipment in the form of pure yeast propagators, such as are used in breweries, is unnecessary and, in fact, dangerous in untrained hands. All that is needed is an outfit of tubs, vats and casks, such as are found in every cellar. These will vary in number and size, according to the scale on which wine is made and the arrangement of the cellar. The yeast apparatus, which was used in our winery experiments during the last vintage, and which is described later, illustrates the principles of the method, and will be found perfectly practical for a small winery. Modifications to facilitate handling and to adapt it to larger operations can easily be devised.

(*e*) *Rejuvenation and Increase of the Pure Culture.* When the culture of pure yeast reaches the winery, it should be as fresh and vigorous as possible. The cellar-man must first determine whether it has the necessary vigor and rejuvenate it, if necessary.

The next step is to increase the amount of pure yeast until it is sufficient to inoculate the first starting tub or vat. The quantity necessary will depend on the size of the apparatus. Up to this point special precautions should be taken to avoid contamination of the culture, and to insure that the yeast used to inoculate the starting tub is quite pure.

The final step is the increase of the yeast in the starting tub until it is sufficient to start the first fermentations. The starting tub or tubs should be large enough to produce each day all the yeast necessary to start all the grapes crushed in one day. A new tub, or series of tubs,

therefore, must be prepared each day during the vintage. The rejuvenation and preliminary increase, however, are needed only for the first. All subsequent tubs are inoculated from the tub of the previous day. Details of the various operations are given below.

*(f) Directions for propagating yeast in wineries.*

**Step I.** *Rejuvenation.* (1) SOLID CULTURES. A culture of pure yeast is received from the station. This culture is contained in a quart bottle, the neck of which is closed with a tight plug of cotton. The interior of the bottle is coated with a layer of solid culture medium, consisting of agar-agar and grape must. In this medium and on its surface the yeast is growing.

1. Obtain one quart of must from clean, sound grapes not overripe and place in a one quart Mason preserving jar, which, with its cover, should be thoroughly sterilized with boiling water before use. The jar should not be filled to nearer than one inch from the top.

2. Place the jar of must in a pot containing enough water to reach about half way up the side of the jar and deep enough, so that it can be covered when containing the jar. Place its cover loosely on the jar, but do not screw down.

3. Cover the pot and place on stove until the water boils. Continue boiling for ten to fifteen minutes.

4. Take the pot from the stove without removing the cover and allow to cool nearly to the temperature of the room.

5. Moisten the cotton plug and the neck of the bottle containing the yeast culture with a little alcohol. Apply a lighted match. This will destroy any spores which have settled on the neck of the bottle.

6. Remove the cotton plug with a pair of pincers, previously sterilized by dipping in alcohol and flaming.

7. Pour the sterilized and cooled must from the Mason jar into the opened bottle containing culture. This is best done by means of a glass or metal funnel, previously sterilized by dipping in boiling water. Avoid all contact of the fingers or other unsterilized surfaces with the neck of the bottle, the inside of the funnel or with the must. The bottle should be filled about four fifths full. Care should be taken not to wet the inside of the neck of the bottle with the must.

8. Pass the cotton plug quickly through the flame of an alcohol lamp and replace in the neck of the bottle.

9. Place the bottle in a warm place until fermentation starts. The temperature of the place should be as near 80° F. as practicable. If it is below 65° F. fermentation will be slow in starting; if much above 90° F. the yeast may be injured. A fireless cooker, containing one or two bottles of water warmed to 95° F., makes a good incubator. A

bucket or box, lined with wood wool ("excelsior"), in which the yeast bottle and two bottles of warm water are buried, and the whole covered with a blanket, is also suitable.

A culture treated in this way should be in full fermentation within twenty-four hours.

(2) LIQUID CULTURES. The manipulation of a liquid culture is similar, but requires some special precautions, owing to the possibility that the yeast is somewhat enfeebled by prolonged immersion in the liquid. The numbers of the paragraphs following correspond to those of the paragraphs above.

1. The quart of must should be placed in a two quart Mason jar, filling it not more than half full. A half gallon demijohn, plugged with cotton wool, and with the wicker cover removed, is even better.

2. Pour the contents of the *bottle* of pure yeast into the sterilized and cooled must in the two quart Mason jar and screw down the top of the latter. If a demijohn is used, replace the cotton with a scalded cork. Shake the mixture thoroughly for five minutes to aerate it. *Loosen* the top of the jar, or replace the cotton plug of the demijohn. This aeration is very necessary if the liquid culture is at all old, and may have to be repeated several times.

**Step 2.** *Increase.* The first step in the process has provided us with 1 quart of young vigorous yeast. This may be used directly to inoculate the first starting tub, but it is safer to increase it a little first unless we are working on a very small scale. At least 5 per cent of pure yeast should be used to inoculate the starting tub. The following directions are for the case where the starting tubs are intended to supply 25 gallons of starter per day, which is sufficient for 2,500 gallons of fermenting grapes; that is, the contents of one medium-sized fermenting vat. The directions can easily be modified for larger quantities.

1. Place $1\frac{1}{2}$ gallons of clean, fresh grape must of about 20 per cent Balling in a two gallon demijohn, from which the wicker cover has been removed, and which has been sterilized with boiling water, and plugged with a tight roll of absorbent cotton.

2. Heat demijohn of must to boiling for fifteen minutes in a covered boiler, containing a few inches of water.

3. Remove from fire and allow to cool.

4. Remove cotton plug carefully and pour the quart of rejuvenated yeast into the demijohn of must, using the same precautions to prevent contamination explained in Step 1.

5. Aerate the must in the demijohn by shaking three or four times at

intervals of three to four hours, and leave in a warm place until vigorous fermentation occurs.

**Step 3.** *Inoculation of Starting Tub.* We now have 1½ gallons of pure yeast, which is sufficient to inoculate 30 gallons of must in a starting tub.

1. About twenty-four hours before the end of Step 2 place about 40 gallons of must in a suitable vat or barrel. Add 2 ounces of potassium metabisulfite (5 ounces per 100 gallons, equivalent to about 175 milligrams of $SO_2$ per liter), and allow to settle for about twenty-four hours. If the must is cold and made from clean, fresh grapes, the amount of sulfite may be reduced one third to one half with advantage.

2. Draw off 30 gallons of this clear, defecated must in to the starting tub and warm to 90° F. with boiling water. If the must is very sweet, the boiling water may be added to it directly. Six gallons of boiling water will raise 24 gallons of must from 60° F. to 90° F. If the must has 24 per cent Balling, the water will reduce it to about 20 per cent Balling. If the must has no excess of sugar, it may be warmed by floating in it a metal bucket or tub of boiling water, or by boiling 5 or 6 gallons of the must.

3. Add the 1½ gallons of yeast obtained by Step 2 to the warmed must in the starting tub.

4. Aerate thoroughly for ten minutes by dipping out bucketfuls of must and pouring back.

5. Cover tub with a canvas sheet to keep out dust and maintain the temperature. Aerate and warm two or three times, if necessary.

6. When the must in the starting tub is in full fermentation, it is ready to use for starting the regular fermentations.

(*g*) *Use of the Starter.* This preparation, which may seem somewhat complicated on paper, is really very simple when understood, and, moreover, is necessary only once. It should be done before the regular crushing of grapes commences, and the first tub of starter should be ready for the first load of grapes.

During the vintage, all that is necessary is to put one gallon of fermenting must from the starting tub into every one hundred gallons of crushed grapes. At the end of the day the fermenting must taken from the tub is replaced with fresh defecated must, and so on until the end of the vintage.

At least 10 per cent of the fermenting must should be left in the tub to start the new must added. If this is done, the starter remains practically pure until the end of the vintage. If the vintage is long, it might be advisable to add a fresh supply of pure yeast, developed from a new pure culture, to the starting tub about the middle of the vintage.

Where the yeast is needed only once a day, a single starting tub is all that is necessary; the size of the tub depending on the amount of yeast needed. Where the yeast is needed all day, it is necessary to have two tubs to be used on alternate days, as the must added at night will not be ready to use the next morning.

(*h*) *Stage of Maximum Efficiency of a Starter.* When we make a new addition of must to a starting tub, we dilute the yeast, so that there is a comparatively small number present in a given volume. The yeast immediately commences to multiply and finally reaches a maximum. It remains at this maximum number for some time, but the yeast cells gradually diminish in vigor.

If we use the starter too soon, therefore, we fail to obtain sufficient yeast cells to give us the full effect; if we use it too late, the yeast cells have lost some of their vigor, they are less efficient in overcoming the competing wild organisms, and the fermentation is slower.

There is theoretically some point between the commencement of fermentation and the end, at which the yeast in the starter has its maximum effectiveness. An experiment was undertaken to determine this point of highest efficiency and to discover some simple means of detecting it.

It is possible to determine the number of yeast cells present by means of a microscopical counting apparatus, but this gives us no measure of the vitality or degree of vigor of these cells. Some of the cells may be young and vigorous, some old and decrepit, some dead. By means of cultures on gelatine plates, a better estimate of the numbers of vigorous cells could be made, but this is troublesome and requires several days. Neither method is suitable for cellar use in the press of the vintage.

The age of the starter gives us a very uncertain measure. The condition of the yeast at the end of a certain number of hours will depend on many conditions, principally the temperature, the number and activity of the cells at the beginning, and the amount of aeration.

A simple guide was found in the disappearance of the sugar. As the development of the yeast progresses, the Balling per cent decreases. A certain decrease of Balling per cent indicates a certain amount of work done by the yeast, and is a measure of the number and vigor of the cells present. It remained to determine at what stage in the decrease of the Balling per cent the yeast possessed its highest efficiency as a starter. The following tests throw light on this matter.

A flask (A) containing must of 22.38 Balling and .75 per cent acidity was inoculated with a non-agglomerating wine yeast. The culture in this flask was used as a starter and a series of flasks, B to L, containing

the same must was inoculated each at different ages of the starter. The Balling per cent of the starter (flask A) was determined at each inoculation and the number of yeast cells present. By observing the course of fermentation in the various flasks we are able to determine what Balling degree of the must in A corresponds to the maximum efficiency of the yeast when used as a starter.

TABLE No. 32.

*Correspondence of Balling per cent and number of yeast cells.*
In Flask A (used as a starter for flasks B to L).

| Hours. | Balling per cent. | Yeast cells per cubic centimeter. | 1 per cent of starter added to |
|---|---|---|---|
| 0 | 22.38 | | |
| 18 | 20.80 | 5,620,000 | Flask B |
| 29 | 18.69 | 74,385,000 | Flask C |
| 43.5 | 13.10 | 122,322,000 | Flask D |
| 51.5 | 11.31 | 166,540,000 | Flask E |
| 66.5 | 7.58 | 175,631,000 | Flask F |
| 74.5 | 4.50 | 187,926,000 | Flask G |
| 80.5 | .13 | 188,462,000 | Flask H |
| 88.5 | 0 | 190,000,000 | Flask I |
| 105.5 | 0 | 191,000,000 | Flask J |
| 113.5 | 0 | 189,000,000 | Flask K |
| 124.5 | 0 | 188,000,000 | Flask L |

Under the conditions of the experiments the number of yeast cells increased very rapidly until about half of the sugar had disappeared. After this it increased slowly until all the sugar was gone. Later it remained practically stationary until the end of the test. The comparative effectiveness of the yeast as a starter at the various stages is shown by the records of the other flasks.

TABLE No. 33.

*Fermentation with starters of various Balling per cents and ages.*

| Flask B. Balling per cent of starter 20.8. | | | Flask C. Balling per cent of starter 18.69. | | |
|---|---|---|---|---|---|
| Hours. | Balling. | Cells per cubic centimeter. | Hours. | Balling. | Cells per cubic centimeter. |
| 0 | 22.38 | | 0 | 22.38 | |
| 10.5 | 21.7 | 6,612,000 | 14.5 | 21.83 | 18,678,900 |
| 25.0 | 19.73 | 87,609,000 | 22.5 | 19.10 | 27,357,150 |
| 33.0 | 16.33 | 107,852,500 | 37.5 | 15.50 | 144,635,700 |
| 48 | 13.26 | 173,565,000 | 44.5 | 11.91 | 150,500,000 |
| 56 | 9.75 | 181,800,000 | 59.5 | 8.53 | 178,060,750 |
| 72 | 6.7 | 181,830,000 | 67.5 | 6.46 | 180,133,000 |
| 80 | 3.62 | | 84.5 | 3.20 | 181,830,000 |
| 97 | 1.03 | 185,951,500 | 93.5 | 1.03 | |
| 106 | 0 | | 108.5 | 0 | 183,635,000 |

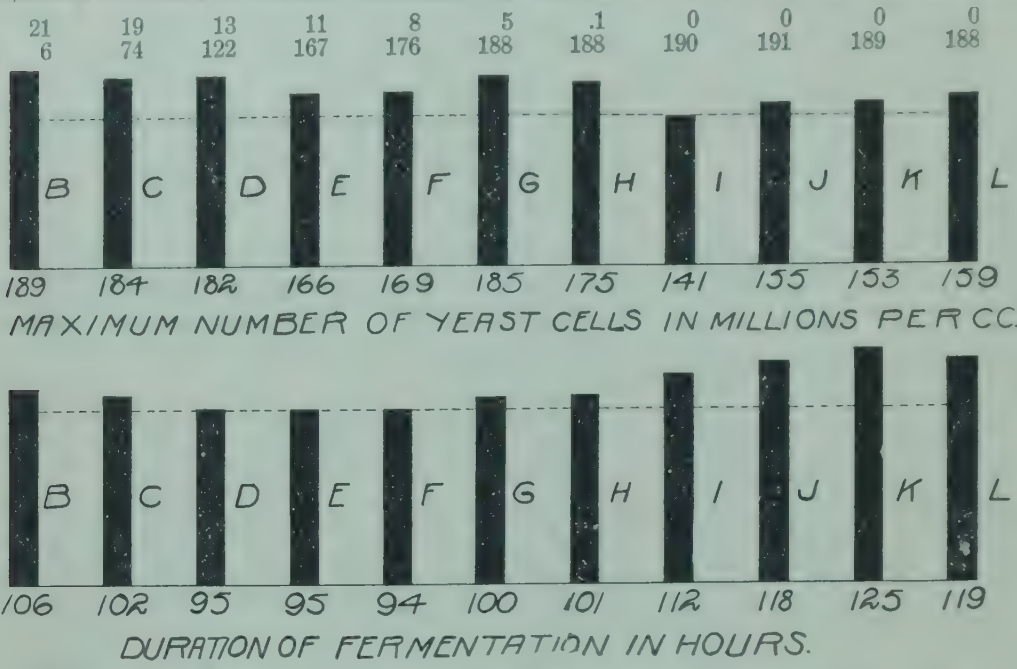
TABLE No. 33—CONTINUED.

*Fermentation with starters of various Balling per cents and ages.*

| Flask D. Balling per cent of starter 13.1. | | | Flask E. Balling per cent of starter 11.31. | | |
|---|---|---|---|---|---|
| Hours. | Balling. | Cells per cubic centimeter. | Hours. | Balling. | Cells per cubic centimeter. |
| 0 | 22.38 | 940,000 | 0 | 22.38 | |
| 8 | 21.83 | 4,264,740 | 15 | 21.59 | 13,214,000 |
| 23 | 20.36 | 89,675,250 | 23 | 20.26 | 64,053,750 |
| 31 | 16.83 | 95,047,500 | 39 | 15.55 | 109,093,000 |
| 47 | 12.95 | 168,606,000 | 47 | 15.03 | 136,372,500 |
| 55 | 10.35 | 172,324,000 | 63 | 8.27 | 144,637,500 |
| 72 | 6.20 | 178,937,250 | 72 | 5.94 | 156,627,300 |
| 81 | 3.87 | | 86 | 2.07 | 157,035,000 |
| 95 | 0 | 181,576,300 | 94 | 0 | 165,300,000 |
| **Flask F. Balling per cent of starter 7.58.** | | | **Flask G. Balling per cent of starter 4.5.** | | |
| 0 | 22.38 | 144,634 | 0 | 22.38 | |
| 8 | 21.57 | 3,925,875 | 17 | 22.36 | 15,124,950 |
| 24 | 18.16 | 55,615,250 | 25 | 20.00 | 60,334,500 |
| 32 | 16.6 | 88,435,500 | 42 | 14.77 | 92,154,750 |
| 50 | 11.91 | 120,975,000 | 51 | 12.17 | 100,923,750 |
| 59 | 8.79 | 133,066,500 | 65 | 7.63 | 103,312,500 |
| 73 | 4.65 | 140,505,000 | 73 | 4.65 | 133,066,500 |
| 81 | 1.55 | 150,325,000 | 89 | .1 | 180,177,000 |
| 97 | 0 | 169,432,500 | 101 | —0 | 183,483,000 |
| **Flask H. Balling per cent of starter .13.** | | | **Flask I. Balling per cent of starter 0.** | | |
| 0 | 22.38 | | 0 | 22.38 | |
| 8 | 21.83 | 2,727,400 | 17 | 22.09 | 14,050,500 |
| 25 | 20.00 | 57,615,250 | 26 | 19.73 | 56,202,000 |
| 33 | 16.86 | 78,517,500 | 40 | 16.1 | 78,517,500 |
| 47 | 12.43 | 107,445,000 | 49 | 11.91 | 99,180,000 |
| 55 | 8.79 | 138,851,000 | 65 | 8.27 | 115,710,000 |
| 71 | 4.78 | 140,505,000 | 77 | 7.24 | 134,719,500 |
| 83 | 2.3 | 152,076,000 | 95 | 2.3 | 135,546,000 |
| 101 | 0 | 175,218,000 | 113 | 0 | 140,505,000 |
| **Flask J. Inoculated 18 hours after starter reached 0.** | | | **Flask K. Inoculated 26 hours after starter reached 0° Balling.** | | |
| 0 | 22.38 | | 0 | 22.38 | |
| 33 | 22.09 | 5,372,250 | 8 | 21.31 | 7,438,500 |
| 47 | 17.7 | 28,927,500 | 24 | 20.78 | 32,233,500 |
| 55 | 17.38 | 55,788,750 | 32 | 19.34 | 85,129,500 |
| 71 | 13.47 | 95,874,000 | 54 | 13.21 | 96,600,500 |
| 83 | 10.87 | 113,230,500 | 72 | 8.27 | 117,189,500 |
| 98 | 6.72 | 129,760,500 | 95 | 3.6 | 142,984,500 |
| 116 | 2.32 | 144,464.000 | 125 | 0 | 152,902,500 |
| 139 | 0 | 154,555,500 | | | |
| **Flask L. Starter used 36 hours after fermentation was over in starting flask.** | | | | | |
| 0 | 22.38 | | | | |
| 8 | 21.83 | 5,785,500 | | | |
| 28 | 20.78 | 64,467,000 | | | |
| 46 | 13.47 | 108,271,500 | | | |
| 69 | 6.9 | 133,066,500 | | | |
| 99 | .5 | 159,514,500 | | | |
| 117 | 0 | 158,614,300 | | | |

DIAGRAM 7.

*Influence of stage of starter (indicated by Balling °) on subsequent fermentation.*




Stage of starter (A) expressed by Balling ° and millions of yeast cells per cubic centimeter (see Table No. 32).

The data of Tables 32 and 33 are brought together in Diagram 7. The fermentation in flasks D, E and F in which the starter was used when the Balling per cent had fallen to 13, 11 and 8 per cent respectively, was the most rapid. In flasks B and C in which the starter was used soon after commencing to ferment the fermentation required about twelve hours more. This was probably due to the fact that the starter contained less yeast and more time was required for the yeast to increase sufficiently to finish the fermentation. In flasks I, J, K and L in which the starter was used after it had ceased to ferment the fermentation was still slower, requiring about twenty-four hours more. This is undoubtedly due to a weakness of the activity of the yeast as the number of yeast cells in the starter was at its maximum when used.

These results indicate that the starter reaches condition of maximum efficiency about the time that the Balling per cent has fallen to 10 per cent. This would probably vary with the Balling per cent of the original must used in making the starter and with other conditions, but as the conditions were in most respects similar to those under which a starter would be prepared in a winery, they justify the advice given to use the starter when about half of the sugar has disappeared.

As the starter must be used for several hours during the day, it would be impracticable to use it always at the point of maximum efficiency, and this is not necessary as it retains very nearly the maximum for some time. A sufficient rule for practice is to wait until 10 per cent of the Balling has disappeared and then use it as long as some sugar still remains.

The time required after the addition of new must to bring a starter to this condition depends principally on the amount of yeast left in the starting tub and on the temperature of the cellar.

If the starter develops too slowly, it can be accelerated by leaving a larger amount of yeast. This will usually control the time perfectly, except in the case where very small yeast tubs are used or in very cold weather, in which cases it may be necessary to warm the liquid. Too rapid development of the starter is to be controlled by the opposite measures. Where very large yeast vats are used, a cooling coil may be necessary.

Winery tests with the simple yeast apparatus described later showed that when a new addition of must was added to the yeast tub at 10 a. m. the yeast was ready for use by 6 a. m. the next morning. It is necessary, therefore, to have only one yeast tub if but a limited number of fermentations are to be started. If fermentations are to be started all day, it would be necessary to have two tubs—one for the morning and one for the afternoon.

The morning tub could be filled at about 10 a. m. and would be ready to use from 6 a. m. to 10 a. m. of the following day, and could be filled immediately with fresh must for the next day. The afternoon tub could be filled at 5 p. m. and would be ready for use from 1 to 5 p. m. of the following day. This would give twenty hours for the yeast to develop to maximum efficiency and four hours in which to use the yeast.

(*i*) *Simple Yeast Apparatus for Wineries.*—The simple apparatus used for our winery tests is suitable for any ordinary cellar and with modifications for large cellars.

For the preliminary operations of the rejuvenation and increase of the pure yeast the following articles are needed:

1. A one quart solid culture of pure yeast.
2. A one quart Mason jar with grape must.
3. A covered saucepan to hold the Mason jar.
4. A small alcohol lamp.
5. A pint of alhohol.
6. A glass funnel to fit into the neck of a quart bottle.
7. A 1 pound roll of surgeon's cotton.
8. Two quart bottles for hot water.
9. A box 16 in. by 16 in. and 24 in. in depth for use as an incubator.
10. Wood wool (excelsior) to fill the incubator.
11. A blanket to cover the incubator.
12. A 2 gallon demijohn without a cover.
13. A wash boiler to hold the 2 gallon demijohn.
14. Four small tubs or vats to hold 50 gallons each.
15. A small scale to weigh 5 pounds, sensitive to ¼ of an ounce.
16. A one pint conical graduate.
17. 5 pounds of potassium metabisulfite.
18. 4 two gallon demijohns to hold the sulfite solution made by dissolving 10 ounces of potassium metabisulfite in one gallon of pure water. One pint of this solution will contain 1¼ ounces of sulfite, which is exactly what is needed to defecate 25 gallons of must.

The incubator, Fig. 7, is a simple wooden box large enough to hold a two gallon demijohn with space for one or two inches of excelsior below, around and above the glass. If the must in the demijohn is

FIG. 6.—Apparatus for the rejuvenation of pure yeast.

warm when put in the box and the whole covered with a thick blanket, it will keep its heat perfectly in the coldest night. A quart bottle requires the aid of a couple of bottles of hot water. The water in these bottles must not be too hot nor the insulation too perfect or the heat evoked by the fermenting must may raise the temperature too high and injure the yeast.

FIG. 7.—Incubator for pure yeast.

An ordinary wash boiler made for heating on a stove is too small to hold a two gallon demijohn upright but will do so if the demijohn is inclined. It is necessary to make some kind of frame to fit into the boiler and hold the demijohn. This frame can be made of wood or of wire. It should keep the demijohn from touching the bottom of the boiler to prevent the direct heat of the fire from cracking the glass. If the inclination of the demijohn is just sufficient to allow the cover of the boiler to be put in place, it will hold the needed $1\frac{1}{2}$ gallons of must.

Two of the fifty gallon vats are for the propagation of the yeast starter and two for the defecation of the necessary must. They should be furnished with faucets at the bottom for drawing off the must and yeast and with wooden or canvas covers to keep out dust. The defecating vats should be placed in such a position that the must can be run directly from them into the yeast vats. The arrangement adopted in our winery tests is shown in Fig. 8 and was found satisfactory.

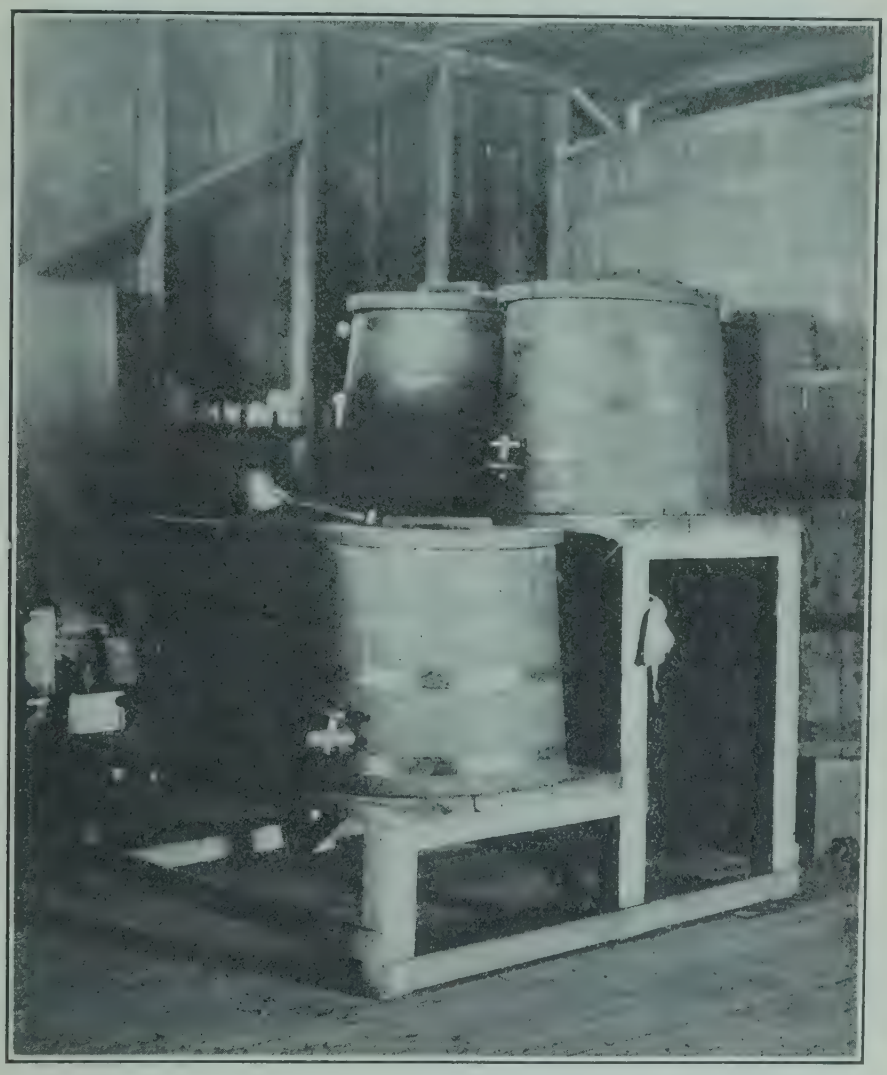


FIG. 8.—Yeast propagating apparatus for a winery.

The battery of vats should be so located that it is easy to supply them daily with must and to convey the yeast to the fermenting vats. It is convenient to label these defecating vats $D_1$ and $D_2$ and the corresponding yeast vats $Y_1$ and $Y_2$.

The first vat of starter $Y_1$ is prepared as described on pages 76 to 78. About 12 to 24 hours before the yeast in this vat is used, 30 gallons

of must should be placed in vat $D_1$ and sulfited with 1 pint of the sulfite solution. This must will be ready for vat $Y_1$ as soon as the yeast in this vat has been used. Before taking yeast out of the vat it should be well mixed in order to stir up the yeast which has settled. After 25 gallons of yeast have been used, 5 gallons remain for the inoculation of the new supply of must. Twenty-five gallons of must are then run directly from vat $D_1$ into vat $Y_1$. It is usually not necessary to warm the must, as the 5 gallons of vigorous young yeast left in the vat insure a prompt start of fermentation which will maintain a favorable temperature if the vat is kept covered. Aeration twice or three times during the day is advisable as it tends to increase the number and vigor of the yeast cells. Vats $Y_2$ and $D_2$ are treated in the same way. By properly timing the sulfiting in vats $D_1$ and $D_2$ and the transference of the defecated must from these vats to vats $Y_1$ and $Y_2$ a continuous supply of yeast can be obtained from 6 a. m. until 6 p. m. The following table will show how this can be done:

TABLE No. 34.

*Times for filling and using defecating and yeast vats.*

| Time. | Vats. | | | |
|---|---|---|---|---|
| | $Y_1$. | $D_1$. | $Y_2$. | $D_2$. |
| September 1, 12 m. | | fill | | |
| September 1, 6 p. m. | | | | fill |
| September 2, 12 m. | fill | fill | | |
| September 2, 6 p. m. | | | fill | fill |
| September 3, 6 a. m. | use | | | |
| September 3, 12 m. | fill | fill | use | |
| September 3, 6 p. m. | | | fill | fill |
| September 4, 6 a. m. | use | | | |
| September 4, 12 m. | fill | fill | use | |
| September 4, 6 p. m. | | | fill | fill |

Thus defecating vat $D_1$ is filled and sulfited at 12 m. every day. Twenty-four hours later at 12 m. of the following day the defecated must is transferred from this vat to yeast vat $Y_1$ and replaced with fresh sulfited must. Eighteen hours later at 6 a. m. of the third day the yeast in vat $Y_1$ is ready for use and can be employed until 12 m. when the vat must be filled again from vat $D_1$. The other pair of vats is treated in the same way except that they are filled at 6 p. m. and used from 12 m. to 6 p. m.

By this arrangement, the sulfited must always defecates for twenty-four hours and the yeast propagates for from eighteen to twenty-four hours, times which have been found suitable and sufficient. Any modifications of these times may be made which allow at least twelve hours for defecation and sixteen hours for fermentation. The defeca-

tion should not last more than forty-eight hours, and the yeast should be used before the must becomes quite dry.

A battery of the size described is sufficient to supply yeast for a winery fermenting 5000 gallons of wine per day. For smaller wineries two vats only might be used; for larger wineries the vats should be larger. A battery consisting of four 500 gallon vats would supply yeast for the fermentation of 50,000 gallons a day. Such a battery should be supplied with cooling coils, aerating device and with hose and small electric or other motor pump to fill the defecating vats and to transport the yeast to the fermentation tanks. One man could do all the work necessary in running the largest apparatus.

(*j*) *Precautions Necessary for the Proper Working of the Yeast Propagation.*

1. CLEANLINESS. Everything that comes in contact with the yeast should be kept clean. Buckets, tubs, hose and pumps used in handling the must and yeast should be washed every time they are used and immediately after using. Rinsing with a sulfite solution is useful but not necessary, if the utensils are placed where they will dry quickly after washing. The yeast vats should be kept covered both to keep out dust and to retain the heat.

2. ACTIONS OF THE SULFITE. The must should not be transferred to the yeast vat until about twelve hours after sulfiting. This is to allow time for the sulfurous acid to enter into the combined form. The wild yeasts and other injurious micro-organisms are thus subjected to the action of the full amount of free $SO_2$ when it is added, while the culture wine yeast comes in contact only with a small amount of free $SO_2$ after the main part has entered into combination. The consequence is that the culture yeast retains its vigor and the wild organisms are paralyzed.

3. MAINTENANCE OF VIGOR OF YEAST. Fresh must should be added to the yeast vats sufficiently often to keep the fermentation going continuously. If the must in the yeast vats is allowed to become perfectly dry the yeast loses in vigor. When this occurs the yeast can be made vigorous again in two or three days by adding fresh must and thoroughly aerating.

4. HASTENING DEVELOPMENT. If the yeast develops too slowly, aerate more and if necessary warm.

5. RETARDING DEVELOPMENT. By leaving a smaller amount of yeast in the vat when adding fresh must, its development can be retarded. This may be done when a day or more passes without crushing as on

Sundays. The yeast left, however, should be at least 5 per cent of the volume of the must added. Less aeration will also tend to retard the growth of yeast.

6. Plan all operations so that the yeast can be used at its maximum efficiency, that is when the Balling per cent has fallen to between 12 per cent and 2 per cent.

## IV. TESTS OF THE USE OF $SO_2$ AND PURE YEAST IN A WINERY.

(a) *Objects and Nature of the Tests.* Laboratory investigations and tests conducted in wineries with the coöperation of the owners have demonstrated thoroughly the utility of the use of pure yeast in combination with sulfurous acid and cooling machines. Many wine-makers, however, have an exaggerated idea of the cost and trouble involved in the use of devices for the control of temperature. The winery tests made this year had for their principal objects the determination of the possibility of introducing some of the benefits of pure yeasts with the help of sulfurous acid, and without any change in the usual methods of the winery involving the installation of cooling machinery or other new appliances except a simple yeast propagator.

Concurrently, observations were made to test on a larger scale certain conclusions reached by means of laboratory experiments.

The tests consisted of parallel series of fermentations, in one of which the ordinary methods of the winery were employed, and in the other, sulfurous acid and pure yeast separately or in combination were applied with as little change in the usual methods as possible. Observations were made on the progress of fermentation and on the development of the wine so long as it was possible to keep the various lots separate. The winery was peculiarly well adapted for the tests proposed. It is situated in a cool region where the need of temperature regulation is less pressing than in most parts of California; the winery is well supplied with the ordinary appliances and labor saving devices; and finally, it received grapes from both interior and coast regions, which enabled us to make our demonstrations on raw materials of differing character.

(b) *Changes in the kind and number of active micro-organisms.* Two vats, each holding 5 tons of grapes, were filled in the ordinary way with Zinfandel from Acampo. Experiment 171, vat 20, received the ordinary treatment of the cellar. Experiment 169, vat 4, was sulfited by the addition of three quarters of a pound of potassium metabi-

sulfite to the ton added gradually as the vat was filled. Five hours after the addition of the last sulfite, 50 gallons of pure yeast were stirred in.

At the start of perceptible fermentation the must in each vat was examined by means of plate cultures. *In the untreated vat nothing was found but molds and wild yeasts; in the treated vat nothing but wine yeast.*

Similar tests were made with two other vats with the following results:

TABLE No. 35.

*Effect of $SO_2$ and pure yeast starter on micro-organisms.*

Experiment 198. Vat 11. Zinfandel from Contra Costa County.

| | Before sulfiting with 12 ounces per ton. | After adding yeast 1.5 per cent starter. |
|---|---|---|
| Molds | 59,400 per c.c. | 0 |
| Wild yeasts | 27,700 | 0 |
| Wine yeasts | 0 | all |

Experiment 202. Vat 19. Second crop Zinfandel from Acampo (very moldy).

| | Sulfite 8 ounces per ton. | | |
|---|---|---|---|
| | Before sulfiting. | After sulfiting. | After adding 1.5 per cent yeast. |
| Molds | 1,600,000 per c.c. | 0 | 0 |
| Apiculate yeast | 2,830,000 | 0 | 0 |
| Other wild yeast | a few | 0 | 0 |
| Wine yeast | a few | 560,000 | 2,816,000 |

Experiment 198 shows that in must from normal, sound, clean grapes, wine yeast exists in very minute quantities. The wild yeasts, (principally *apiculatus*) on the contrary, are numerous. Such a must allowed to ferment spontaneously without the addition of sulfurous acid or pure yeast would not develop wine yeast in appreciable quantities, until the apiculatus had multiplied sufficiently to seriously affect the quality of the wine. This is shown by experiment 202 where, owing to injury to the grapes and delay in crushing, the apiculatus yeast has increased a hundredfold. The first part of the fermentation of all our grapes is undoubtedly due to apiculatus when measures are not taken to prevent it. Much of the persistent cloudiness and delay in the finish of fermentation, even of otherwise good wines, is due to this cause.

The trouble with apiculatus fermentation is likely to be worse in the cleanest and best kept wineries and at the beginning of the season. When crushers, vats and other surfaces, with which the grapes come in contact are kept constantly covered with grape must the wine yeast

finally develops and inoculates the must. This is a defective method of obtaining wine yeast, however, as it gives no assurance of the kind of yeast and introduces also injurious bacteria.

The mold spores, while even in good grapes as numerous as the wild yeasts, are innocuous if the grapes are crushed while still in good condition as they do not increase appreciably in the must or crushed grapes. If delay occurs in the crushing, however, they may increase rapidly as shown by experiment 202, in which case they may seriously injure the wine.

In all three cases the injurious molds and yeasts were eliminated or paralyzed completely, even in vat 19 containing grapes in very bad condition. The number of wine yeast cells was so much smaller than that of the wild forms that before sulfiting it was difficult to find any at all. After sulfiting, however, in vat 19 they were found to exist in fair numbers. Sulfiting alone, therefore, would have insured a fermentation due principally to wine yeast in this case, though the molds and apiculatus yeasts had undoubtedly injured the must before the sulfite was added.

In vat 11 containing grapes in good condition, a starter of pure yeast insured a fermentation due practically entirely to the yeast added. In vat 19 the yeast to which the fermentation was due consisted of about four parts of that added to one part of the wine yeast occurring naturally on the grapes. This shows that even with grapes in very bad condition much improvement may be expected from sulfiting and pure yeast. The injurious yeasts are all eliminated and the slight admixture of the natural wine yeasts can do no harm.

These experiments show that the injurious activities of molds and wild yeasts can be prevented by prompt crushing and sulfiting followed by the addition of a starter of good wine yeast.

(c) *Duration and Course of the Fermentation.* 1. FERMENTATION CURVES. When a cask of grape must is allowed to ferment spontaneously the fermentation is not uniform throughout its course. There is first of all a period during which no fermentation is perceptible. This is because the yeasts present are insufficient to cause any noticeable changes in the mass. During this period the yeasts and other organisms increase in number until finally the mass exhibits signs of fermentation. These signs are rise of temperature, evolution of gas and decrease of sugar as shown by the Balling saccharometer. The yeasts continue to increase and the fermentation, at first slow, becomes more and more rapid until it reaches a maximum. After this the fermentation gradually becomes slower until it ceases completely. If it ceases before all the sugar has been destroyed it is said to "stick."

The character of the fermentation can be shown graphically by a

line or curve indicating the rate of fermentation at all points of its course. Curves of this kind can be made from observations of the volume of gas given off, of changes in the weight of the fermenting mass, of the rise of temperature or of the decrease of Balling per cent. The changes in the sugar contents as shown by the Balling saccharometer afford a very simple and useful means of forming a fermentation curve.

The shape of this curve shows the progress of the fermentation and the changes in its rapidity. The rapidity of the fermentation is influenced by a number of factors. It is the greater the larger the number of active yeast cells present and within certain limits the more fermentable matters contained in the must. It tends to decrease as the products of fermentation, alcohol, volatile acids, etc., accumulate in the must. Aeration tends to hasten the fermentation by promoting the multiplication of the yeast. High temperatures, within certain limits, accelerate the rate of fermentation by increasing the number of yeast cells and rendering them more active.

A typical fermentation curve is shown in Diagram 8. This represents a fermentation of sterilized must started with 1 per cent of vigorous yeast and kept at a nearly constant temperature.

Three periods may be distinguished, a fore period of two days in which the fermentation is slow, removing an average of 2° Balling per day; a central period of four days in which the fermentation is nearly twice as rapid, removing an average of $3\frac{3}{4}$° Balling per day; and an after period of $3\frac{1}{2}$ days in which fermentation becomes slow again, removing an average of only $1\frac{1}{3}$° Balling per day. If the temperature had been lower or the amount of yeast added less, the whole fermentation and especially the fore period would have been longer. If more aeration had been given the whole fermentation and especially the central period would have been shorter.

Curves of the fermentations that occur in practice in the winery show many interesting and instructive variations of this type.

The part showing the fore period is usually much longer and flatter. This is because the amount of yeast present in the freshly crushed grapes is small and the temperature low. It may be curtailed by the addition of a starter or by warming the must. It may be prolonged by the use of sulfites. Occasionally there is an actual rise of the curve during the fore period. This is due to the sugar in dried grapes, which diffuses into the must before noticeable fermentation commences.

The part showing the central period is usually shorter and steeper, particularly in red wine fermentations. This is because of greater aeration and a rise in temperature. It may be prolonged slightly by the use of cooling devices.

The part showing the after period often exhibits great variations. In very sweet musts it may be very much prolonged, may even last for months, and in some cases may become horizontal, showing a cessation of fermentation before 0 Balling° is reached. This is due to the accumulation of products of fermentation such as alcohol and volatile acids, which interfere with the action of the yeast. Aeration and maintaining the temperature are the principal means of preventing the undue lengthening of this period. Where the fermentation is pure and the temperature is high, especially in weak musts, this period may be much curtailed.

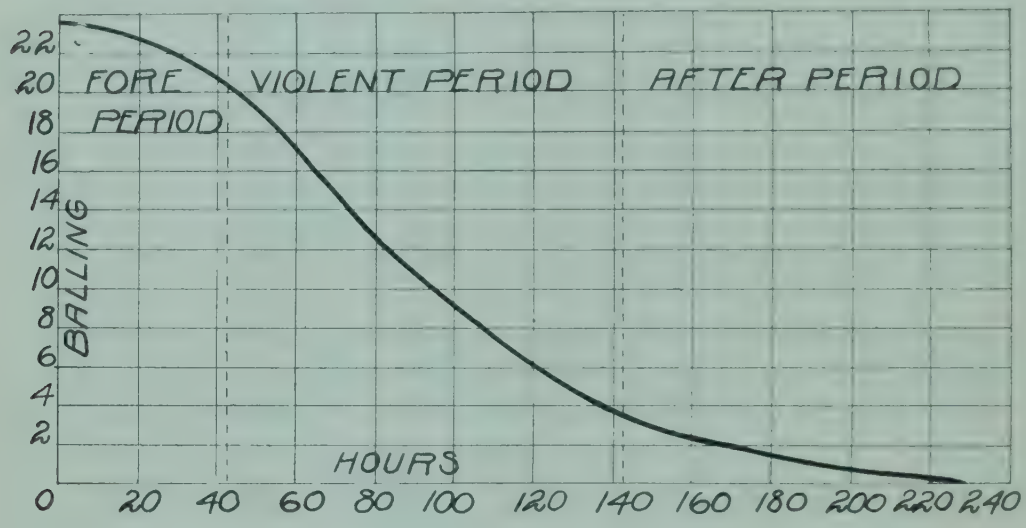



DIAGRAM 8.

**Typical fermentation curve at constant temperature.**

2. RED WINE FERMENTATIONS. Observations were made on the following red wine fermentations at Martinez:

| Variety and origin of grapes. | Sulfite per ton. | Pure yeast. | Fermenting vats. | Storage casks. |
|---|---|---|---|---|
| I. Zinfandel from Acampo | 0 | 0 | 2 | 10 |
| II. Zinfandel from Acampo | 0 | 0 | 5 | |
| III. Zinfandel from Acampo | 5 oz. | plus | 3 | 1 |
| IV. Zinfandel from Acampo | 12 oz. | plus | 1 | 9 |
| V. Zinfandel from Acampo | 12 oz. | plus | 4 | |
| VI. Petite Sirah from Acampo | 0 | 0 | 9 | 2 |
| VII. Petite Sirah from Acampo | 8 oz. | plus | 7 | 16 |
| VIII. Petite Sirah from Acampo | 12 oz. | plus | 10 | |
| IX. Zinfandel from Contra Costa Co. | 0 | 0 | 20 | *10-11 |
| X. Zinfandel from Contra Costa Co. | 12 oz. | plus | 8 | 12 |
| XI. Zinfandel from Contra Costa Co. | 12 oz. | plus | 11 | |
| XII. Alicante Bouschet from Acampo | 8 oz. | plus | 12 | 17 |
| XIII. Alicante Bouschet from Acampo | 8 oz. | plus | 15 | |
| XIV. Petite Sirah and Green Hungarian | 9 oz. | 0 | 6 | 18 |
| XV. Barbera from Contra Costa Co. | 5 oz. | 0 | 14 | 4 |
| XVI. Zinfandel, 2d crop from Acampo | 8 oz. | plus | 19 | 2 |
| XVII. Alicante Bouschet from Acampo | 8 oz. | 0 | 13 | 26 |
| XVIII. Zinfandel and Alicante Bouschet from Contra Costa Co. | 6.5 oz. | plus | 16 | |
| XIX. Alicánte Bouschet from Contra Costa Co. | 8 oz. | plus | 17 | |
| XX. Zinfandel from Contra Costa Co. | 8 oz. | plus | 18 | |

*Puncheons.

The fermentations were all conducted in vats with 5-foot staves, holding about 2,200 gallons. No cooling was used, and, as a consequence, the temperatures in all cases were high. The temperature conditions of the locality and of the season were exceptionally favorable. The cellar varied on the average from about 61° F. at night to about 74° F., in the hottest part of the day. On the hottest day it rose to 84° F., and on the coldest night it fell to 54° F. Under less favorable conditions there would undoubtedly have been more trouble with "stuck" wines. The variations in the temperature of the air of the fermentation room during the vintage are shown by the curves of diagram 9.

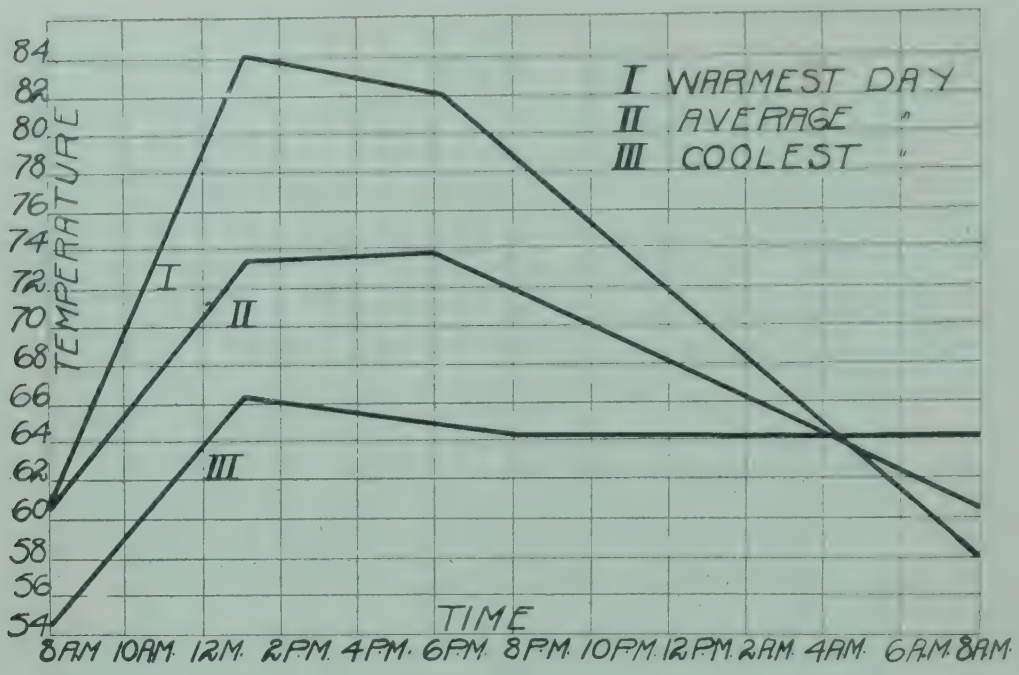



DIAGRAM 9.

Variation in temperature of fermenting room.

The grapes, after stemming and crushing, were conveyed by means of a must pump directly to the fermenting vats. The sulfurous acid was added in fractional doses gradually as the vats were filled and mixed by repeated stirring. The sulfurous acid was used in the form of a strong water solution of potassium metabisulfite. After allowing the sulfited grapes to stand for some hours, 30 to 40 gallons of yeast were added. This represents a starter of from $1\frac{1}{2}$ to 2 per cent. The yeast was mixed as thoroughly as possible by means of punching. A better method would have been to pump over the must, as soon as the vat was filled, to distribute the sulfite equally and again while adding the yeast.

The vats were kept covered until the temperature began to rise, when the covers were removed and punching practised three times a day. When the temperature commenced to fall, the covers were replaced unless the vats were drawn off immediately. In most cases the drawing off was delayed until the Balling had fallen to 0°. A record was kept of the disappearance of the sugar and of the changes in temperature.

The first series of fermentations was made with Zinfandel grapes from Acampo, San Joaquin County. The grapes were in fair to poor condition, the different lots containing a smaller or larger proportion of dried and moldy grapes. Two vats were allowed to ferment in the ordinary way without sulfite or starter. One vat was sulfited at the

rate of 5 ounces to the ton, and two at the rate of 12 ounces. All three sulfited vats were started with pure yeast.

TABLE No. 36.

*Fermentation I. Zinfandel from Acampo, Vat No. 2, ordinary fermentation, no sulfite, no starter.*

| Date. | Hour. | Balling per cent. | Temperature. | | | Remarks. |
|---|---|---|---|---|---|---|
| | | | Cap. | Bottom. | Room. | |
| Oct. 24 | 8 a. m. | 23.6 | ---------- | 59.0 | 54.5 | Started to fill vat. Grapes show many raisins. |
| Oct. 24 | 2 p. m. | 23.7 | ---------- | 59.0 | 69.0 | Vat half full. Grapes a little cleaner than in Vat 1. |
| Oct. 25 | 7 a. m. | 24.1 | ---------- | 57.0 | 54.5 | Slight signs of fermentation |
| Oct. 25 | 8 p. m. | 24.6 | ---------- | 60.0 | 64.5 | Slow fermentation. Smell of $CO_2$ gas. |
| Oct. 26 | 8 a. m. | 24.8 | ---------- | 57.0 | 61.0 | Slow fermentation. Smell of $CO_2$ gas. |
| Oct. 26 | 9 p. m. | 24.2 | ---------- | 59.0 | ---------- | Gas coming off freely. |
| Oct. 27 | 8 a. m. | 24.1 | ---------- | 59.0 | ---------- | Fermentation vigorous. |
| Oct. 27 | 9 a. m. | ---------- | ---------- | ---------- | ---------- | Started to complete filling of vat. |
| Oct. 27 | 2:30 p. m. | ---------- | ---------- | ---------- | ---------- | Vat full. |
| Oct. 27 | 8 p. m. | 22.7 | 64.5 | 73.5 | 61.0 | Fermentation of the grapes first crushed has raised the temperature of the bottom |
| Oct. 28 | 8 a. m. | 22.1 | 70 | 66.0 | 59.0 | |
| Oct. 28 | 12 m. | 20.5 | 70 | 69.0 | 71.5 | Temperature taken after punching. |
| Oct. 28 | 8 p. m. | 16.0 | 80 | 78.0 | 70.5 | Temperature taken after punching. |
| Oct. 29 | 8 a. m. | 5.5 | 97 | 91.5 | 59.0 | |
| Oct. 29 | 11 a. m. | 2.7 | 99.5 | ---------- | 71.5 | |
| Oct. 29 | 4 p. m. | 1.6 | 100.5 | 100.5 | 72.5 | Fermentation subsiding. |
| Oct. 29 | 10:30 p. m. | 0 | ---------- | 97.0 | ---------- | Drew off free run into cask 10. |

The rise of Balling per cent from 23.6 to 24.8 during the first forty-eight hours is due to the presence of numerous dried grapes. It is not considered good practice to spread the filling of a vat over two or three days, as in this case, although it is said to promote the dissipation of some of the heat of fermentation where cooling devices are not employed. This tendency is very slight, however, as the temperature in fermentation II only rose about two degrees higher than in I, although the original temperature of the grapes was about 12 degrees higher.

TABLE No. 37.

*Fermentation II. Zinfandel from Acampo, Vat No. 5, ordinary fermentation, no sulfite, no pure yeast.*

| Date. | Hour. | Balling per cent. | Temperature. | | | Remarks. |
|---|---|---|---|---|---|---|
| | | | Cap. | Bottom. | Room. | |
| Oct. 29 | 10 a. m. | ---- | ---- | ---- | ---- | Began filling vat. |
| Oct. 29 | 6 p. m. | ---- | ---- | ---- | ---- | Vat filled and covered. |
| Oct. 29 | 8 p. m. | 21.7 | ---- | 71.5 | 70.5 | Slight signs of fermentation. |
| Oct. 30 | 8 a. m. | 22.0 | ---- | 64.5 | 61.5 | |
| Oct. 30 | 8 p. m. | 22.5 | ---- | 64.5 | 71.5 | |
| Nov. 1 | 8 a. m. | 23.0 | 68.0 | 69.0 | 62.5 | Slow fermentation. |
| Nov. 1 | 12 m. | 22.5 | 68.0 | 69.0 | 71.5 | Slow fermentation. |
| Nov. 1 | 8 p. m. | 22.0 | ---- | ---- | 64.5 | Fermentation well started. |
| Nov. 2 | 9 a. m. | 17.0 | 79.0 | 77.0 | 59.0 | Fermentation vigorous. |
| Nov. 2 | 12 m. | 12.0 | 84.0 | 82.5 | 68.0 | |
| Nov. 2 | 10 p. m. | 4.0 | 100.5 | 99.5 | 68.0 | |
| Nov. 3 | 8 a. m. | 1.0 | 102.0 | 101.5 | 59.0 | |
| Nov. 3 | 8 p. m. | .3 | 100.5 | 100.5 | 57.0 | Fermentation slackening. |
| Nov. 4 | 8 a. m. | .2 | 97.0 | 97.0 | 61.0 | Drew off free run into cask 10. |

This vat also shows a rise in Balling in the first forty-eight hours, due to the presence of dried grapes.

TABLE No. 38.

*Fermentation III. Zinfandel from Acampo, Vat No. 3, sulfite 5 ounces per ton, pure yeast.*

| Date. | Hour. | Balling per cent. | Temperature. | | | Remarks. |
|---|---|---|---|---|---|---|
| | | | Cap. | Bottom. | Room. | |
| Oct. 27 | 2 p. m. | ---- | ---- | ---- | ---- | Started filling vat. |
| Oct. 27 | 3 p. m. | ---- | ---- | ---- | ---- | Added 8 ounces sulfite. |
| Oct. 27 | 4 p. m. | ---- | ---- | ---- | ---- | Added 8 ounces sulfite. |
| Oct. 27 | 6 p. m. | ---- | ---- | ---- | ---- | Added 16 ounces sulfite. |
| Oct. 27 | 6:15 p. m. | ---- | ---- | ---- | ---- | Added 8 ounces sulfite. |
| Oct. 27 | 6:30 p. m. | ---- | ---- | ---- | ---- | Added 5 ounces sulfite. |
| Oct. 27 | 10:30 p. m. | ---- | ---- | 67.0 | 61.0 | Added starter of yeast. |
| Oct. 28 | 8 a. m. | 22.3 | ---- | 67.0 | 60.0 | No visible fermentation. |
| Oct. 28 | 12 m. | 22.3 | ---- | 66.0 | ---- | Fermentation started very slightly. |
| Oct. 28 | 8 p. m. | 22.3 | 66.0 | 66.0 | 71.0 | |
| Oct. 29 | 8 a. m. | 22.2 | ---- | 68.0 | 61.0 | |
| Oct. 29 | 12 m. | 20.2 | 71.5 | ---- | 70.0 | Fermentation well started. |
| Oct. 29 | 8 p. m. | 16.2 | 82.5 | 75.0 | 70.0 | Fermentation vigorous. |
| Oct. 30 | 8 a. m. | 14.9 | 82.5 | ---- | 61.5 | |
| Oct. 30 | 12 m. | 11.5 | 88.0 | 86.0 | 76.0 | |
| Oct. 30 | 6 p. m. | 6.7 | 89.5 | 86.0 | 68.0 | |
| Oct. 30 | 8 p. m. | 5.0 | 97.0 | 97.0 | 73.5 | |
| Nov. 1 | 8 a. m. | 1.2 | 100.5 | 100.5 | 62.5 | |
| Nov. 1 | 10:39 a. m. | .9 | ---- | 100.5 | 64.5 | |
| Nov. 1 | 4 p. m. | .3 | ---- | ---- | ---- | Drew off free run into cask 1. |

TABLE No. 39.

*Fermentation V. Zinfandel from Acampo, Vat. No. 4; sulfite, 12 ounces per ton; pure yeast.*

| Date. | Hour. | Balling per cent. | Temperature. | | | Remarks. |
|---|---|---|---|---|---|---|
| | | | Cap. | Bottom. | Room. | |
| Oct. 23 | 10 a. m. | 21.9 | | | | Started filling vat; grapes very moldy. |
| Oct. 23 | 10:30 a. m. | | | | | Added 8 ounces sulfite. |
| Oct. 23 | 11:30 a. m. | 23.2 | | 64.5 | | Added 24 ounces sulfite. |
| Oct. 23 | 2:30 a. m. | | | | | Added 32 ounces sulfite. |
| Oct. 23 | 6 p. m. | | | | | Added 40 ounces sulfite. |
| Oct. 24 | 9 a. m. | 22.5 | | 64.5 | 54.5 | |
| Oct. 24 | 9 p. m. | 22.5 | | 64.5 | 64.5 | No fermentation. |
| Oct. 25 | 7:30 a. m. | 22.5 | | 62.5 | 54.5 | A few bubbles of $CO_2$. |
| Oct. 25 | 8:30 a. m. | | | | | Added 15 ounces sulfite. |
| Oct. 25 | 11:30 a. m. | 22.5 | | | 66.0 | Added 50 gallons pure yeast. |
| Oct. 25 | 8 p. m. | 23.5 | | 68.0 | 64.0 | Slight fermentation. |
| Oct. 26 | 1 p. m. | 23.6 | 70.0 | 68.0 | 64.5 | Fermenting slowly. |
| Oct. 26 | 9:45 p. m. | 23 | | 68.0 | 61.0 | Fermenting well. |
| Oct. 27 | 7:45 a. m. | 22.7 | | 68.0 | | |
| Oct. 27 | 11:40 a. m. | 22.1 | 70.0 | 68.0 | | |
| Oct. 27 | 8 p. m. | 20.5 | 74.5 | 71.5 | 61.0 | |
| Oct. 28 | 8 a. m. | 16.3 | 95.0 | 82.5 | 60.0 | Removed cover. |
| Oct. 28 | 12 m. | 11.2 | | 84.0 | 71.5 | |
| Oct. 28 | 8 p. m. | 5.3 | 100.5 | 97.0 | 70.5 | |
| Oct. 28 | 12 p. m. | 2.5 | 100.5 | 98.5 | | |
| Oct. 28 | 1 a. m. | | | | | Drew off into cask 9. |
| Oct. 28 | 2:30 a. m. | 2.7 | 97.0 | | | |
| Oct. 29 | 8 a. m. | 1.8 | | 99.5 | | |
| Oct. 29 | 11:30 a. m. | .7 | | 100.5 | 70.0 | |

This fermentation shows very clearly the ineffectiveness of $SO_2$ in controlling temperature. The temperature reached 97° F., while the must still showed over 5° Balling. The wine, however, continued to ferment and became dry. Without the sulfite it would probably have "stuck" and remained sweet.

TABLE No. 40.

*Fermentation IV. Zinfandel from Acampo, Vat. No. 4; sulfite, 12 ounces per ton; pure yeast.*

| Date. | Hour. | Balling per cent. | Temperature. | | | Remarks. |
|---|---|---|---|---|---|---|
| | | | Cap. | Bottom. | Room. | |
| Oct. 28 | 8 a. m. | | | | | Commenced to fill vat. |
| Oct. 28 | 10:30 a. m. | | | | | Vat filled; 7½ pounds of sulfite added in all. |
| Oct. 29 | 3 p. m. | 22.7 | | | | Added 40 gallons pure yeast. |
| Oct. 30 | 8 a. m. | 22.7 | | 66.0 | 61.5 | Slight signs of fermentation. |
| Oct. 30 | 8 p. m. | 22.3 | 71.5 | 64.5 | 71.5 | |
| Nov. 1 | 8 a. m. | 22 | 70.5 | 68.0 | 62.5 | Vigorous fermentation. |
| Nov. 1 | 8 p. m. | 20 | 68.0 | 68.0 | 64.5 | |
| Nov. 2 | 7 a. m. | 16 | 89.5 | 71.5 | 61.0 | |
| Nov. 2 | 12 m. | 12 | 84.0 | 82.5 | | |
| Nov. 2 | 10 p. m. | 3.5 | 98.5 | 97.0 | 71.5 | |
| Nov. 3 | 8 a. m. | 0 | 100.5 | 100.5 | 59.0 | |
| Nov. 3 | 2 p. m. | | | | | Drew off free run into cask 9. |

The foregoing tables and diagram 10, made from them, afford us a means of judging of the influence of sulfiting and starters on the course of the fermentations. A comparison of the five fermentations is made in Table 41.

TABLE No. 41.

*Comparison of fermentations with and without $SO_2$ and pure yeast. Summary of Fermentations I, II, III, IV and V.*

| | Balling per cent. | Temp. | Sulfite. | Yeast. | Fermentation. | | | Sugar lost per 24 hours. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Commenced. | Lasted. | Total. | A From filling. | B From starting. | C From visible ferment. |
| I | 24.8 | 59.0 | 0 | 0 | 52 hrs. | 82 hrs. | 134 hrs. | 4.44 | 4.44 | 7.26 |
| II | 23.0 | 71.6 | 0 | 0 | 36 hrs. | 72 hrs. | 108 hrs. | 5.11 | 5.11 | 6.67 |
| III | 22.3 | 67.1 | 5 oz. | 4 hrs. | 34 hrs. | 58 hrs. | 92 hrs. | 5.82 | 6.08 | 9.23 |
| IV | 23.6 | 64.4 | 12 oz. | 50 hrs. | 67 hrs. | 79 hrs. | 146 hrs. | 3.88 | 5.90 | 7.17 |
| V | 22.7 | 66.0 | 12 oz. | 29 hrs. | 50 hrs. | 68 hrs. | 118 hrs. | 4.62 | 6.12 | 8.01 |

The third column from the end (A) shows the influence of the combination of sulfite and a starter on the total time of fermentation. During the 134 hours, which the fermentation of No. I lasted, an average of 4.44 per cent Balling was lost every twenty-four hours. No. II required less time, 5.11 per cent Balling disappearing in twenty-four hours. This difference was due to the higher temperature of the grapes of No. II when crushed.

In No. III, 5.82 per cent Balling disappeared in twenty-four hours, which is more than shown by either untreated vat. This shows that the delay due to a small dose of sulfite is less than the gain in time, due to the addition of yeast, if the starter is added soon after the sulfiting.

In No. IV fifty hours elapsed from the crushing of the grapes until the addition of the starter. The use of the starter did not compensate for this loss of time and only 3.88 per cent Balling disappeared in twenty-four hours. In No. V, twenty-nine hours were allowed to elapse between the sulfiting and the addition of the starter, and the sugar disappeared at the rate of 4.62 per cent Balling in twenty-four hours. This rate is intermediate between the two untreated vats, and is just about what might have been expected from the original temperature of the grapes, which is also intermediate between those of the untreated vats.

These results indicate that a delay of the fermentation of twenty-four hours, due to sulfiting, can be overcome by the use of a starter. As other results show that the starter is best used within six to twelve hours after sulfiting, the combination of sulfite and pure yeast gives a net gain in the time of fermentaion. This gain is due to the time

TABLE No. 57.

*Influence of $SO_2$ and pure yeast on the color of red wines.*

| Fermentation. | No sulfite. | | Sulfite. | |
|---|---|---|---|---|
| Zinfandel, I, II | 5 VR | 44 | | |
| Zinfandel, III | | | 4 VR | 35 |
| Zinfandel, IV, V | | | 4 VR | 52 |
| Petite Sirah, VI | 2 VR | 93 | | |
| Petite Sirah, VII, VIII | | | 1 VR | 121 |
| Zinfandel, IX | 3 VR | 35 | | |
| Zinfandel, X, XI | | | 3 VR | 66 |
| Means | | 56 | | 69 |

In the Zinfandel of the first series the sulfited wines show a slight improvement of tint but the intensity of the color is in one case slightly less and in the other slightly more than in the unsulfited. This is really a favorable showing, as the unsulfited grapes were riper and therefore more deeply colored. In the other series the sulfited showed from 30 per cent to 80 per cent more color than the corresponding unsulfited wines. The average of all the wines showed an increase of about 23 per cent.

6. CONDITION. The condition of a young wine means its degree of limpidity or the amount and character of suspended solid matter it contains. A wine during and immediately after fermentation is said to be "murky or muddy." After the main part of the yeast and other sediment has settled it is said to be "cloudy." When it is sufficiently freed from floating matter to be transparent it is called "clear." The final stage of limpidity is reached when the most careful scrutiny fails to detect any visible floating particles. The wine is then said to be "bright."

These various stages occupy various periods according to the soundness of the wine and the methods of handling. A wine will lose its gross sediment and reach the "cloudy" stage within a few days after the end of perceptible fermentation. The length of time during which wines remain "cloudy" will vary from a few days to many months. A perfectly sound and properly fermented wine should be "clear" within three weeks of pressing in the case of red wine and within six or eight weeks in the case of white. Clearing is delayed by unfermented sugar and the presence of many bacteria. It is hastened and facilitated by suitable aeration and temperature.

The rapid clearing of the wine was a constant effect of the use of sulfurous acid and pure yeast owing to the more perfect elimination of the sugar and the prevention of bacterial and wild yeast action.

7. SULFUROUS ACID REMAINING IN THE WINE. In Table 58 is shown the amount of total $SO_2$ found in the wines fermented in the presence of sulfites. For the white wines the amount of free $SO_2$ found is also given. The determinations were made at the beginning of February when the wines were about four months old.

TABLE No. 58.

*Sulfurous acid remaining in the wine.*

| Red wines. | Sulfite added per ton. | Equivalent $SO_2$ per cent. | Per cent of $SO_2$ found in wine. |
|---|---|---|---|
| Zinfandel, III | 5 oz. | .0078 | .0040 |
| Zinfandel, IV, V | 12 oz. | .0188 | .0076 |
| Petite Sirah, VII, VIII | 10 oz. | .0156 | .0076 |
| Zinfandel, XXI | 12 oz. | .0188 | .0096 |
| Alicante Bouschet, XII, XIII | 8 oz. | .0125 | .0108 |
| Zinfandel, XVI | 8 oz. | .0125 | .0108 |
| Miscellaneous | 8 oz. | .0125 | .0096 |
| **White wines.** | **Free $SO_2$ per cent found in wine.** | **$SO_2$ per cent added.** | **Per cent of $SO_2$ found in wine.** |
| Green Hungarian, IV | .0013 | .0188 | .0154 |
| Green Hungarian, V | .0013 | .0188 | .0149 |
| Green Hungarian, VII | .0012 | .0188 | .0154 |
| Green Hungarian, VIII | .0010 | .0188 | .0159 |
| Green Hungarian, IX | .0013 | .0188 | .0151 |
| Palomino, XI | .0015 | .0500 | .0418 |
| Palomino, XII | .0015 | .0500 | .0340 |

These analyses show that at four months from 14 per cent to 60 per cent of the total sulfurous acid added to the must had disappeared from the red wine and from 16 per cent to 30 per cent from the white. There is, therefore, no danger of exceeding the legal limit, which is sufficiently high for all the legitimate purposes of the wine-maker. Even in the Palomino, where from 3 to 4 times as much sulfite was used as was necessary or desirable, the $SO_2$ in one puncheon had already fallen below the legal limit.

The amount of free $SO_2$ was very low in all the wines—so low that in the red wines its exact determination was difficult.

needed by the natural yeast of the grapes to multiply sufficiently to cause perceptible fermentation.

In cellars where the vats, crushers and conveyors are allowed to remain covered with grapes and must they may supply a natural starter. If this starter happens to be principally wine yeast, the consequent fermentation may finish sooner than that of a sulfited vat started with pure yeast. If the natural starter, however, as will usually be the case, contains a large proportion of injurious organisms the fermentation may be much longer, owing to delay in the latter part.

The second column from the end (B) shows the rate of disappearance of the sugar after the addition of the starter in III and IV and V. If we compare these figures with those of I and II in the third column from the end, we eliminate the effect of the sulfite, and have a measure of the effect of the starter alone. This indicates a considerable increase in the rate of fermentation. Basing the calculation on a comparison of No. IV with the mean of Nos. I and II, we have an increased rate of fermentation of about 23 per cent.

Finally, in the last column we have some light on the influence of the sulfite alone. The figures give the average loss of sugar per twenty-four hours from the start of visible fermentation to its completion at 0 per cent Balling. The most rapid loss is in No. III, which received a small dose of sulfite. No. II in spite of the higher temperature of the grapes, fermented at a rate about 17 per cent slower. This might indicate a superiority of the added pure yeast, but more probably indicates that in No. II the growth of wild yeasts diminished the activity of the natural wine yeast. Nos. IV and V, which received a larger dose of sulfite, fermented at about the same rate as Nos. I and II, which received none. This seems to indicate that the weakening effect in the yeasts of such doses of $SO_2$ was in this case about equal to that of the wild yeasts, so far as the activity of the fermentation is concerned. The effect on the quality of the wine, however, is quite different. The wild yeasts depreciate the quality of the wine, and may prevent the completion of the fermentation. No such effects have been noted to follow the use of these doses of $SO_2$.

A comparison of these five fermentations is made by the curves of diagram 10. The time of the addition of the pure yeast starter is shown at the right of the diagram. The curve beyond this time should be compared with the whole curve of the unsulfited vats. The whole work of the yeast is shown in this way to have required from $4\frac{1}{2}$ to 6 days in the unsulfited vats and from $3\frac{1}{2}$ to 4 days in the sulfited. The tumultuous fermentation, however, was more rapid in the unsulfited, as shown by the steeper curve representing this stage.

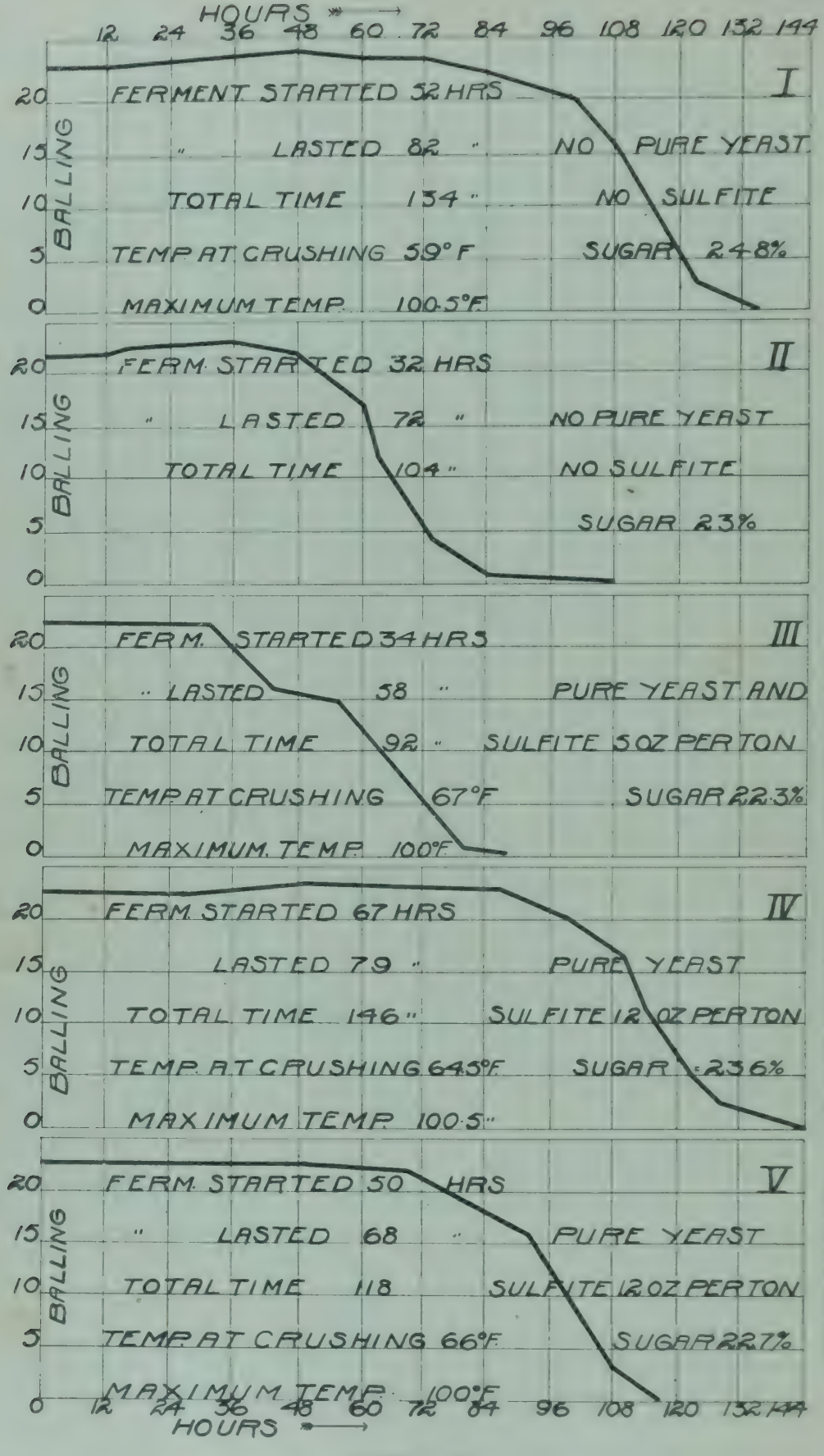



DIAGRAM 10.

Fermentation curves of Acampo Zinfandel.

TABLE No. 42.

*Fermentation VI. Petite Sirah from Acampo, Vat No. 9, no sulfite, no starter.*

| Date. | Hour. | Balling per cent. | Temperature. | | | Remarks. |
|---|---|---|---|---|---|---|
| | | | Cap. | Bottom. | Room. | |
| Nov. 6 | 9 a. m. | -------- | -------- | -------- | -------- | Commenced to fill vat. |
| Nov. 6 | 6 p. m. | 21.0 | -------- | 72.5 | 72.5 | |
| Nov. 7 | 8 a. m. | 21.2 | -------- | 61.5 | 60.0 | |
| Nov. 7 | 1 p. m. | 22.5 | -------- | 62.5 | 71.5 | |
| Nov. 7 | 6 p. m. | 22.1 | 62.5 | 62.5 | 73.5 | Fermenting slowly. |
| Nov. 8 | 8 a. m. | 21.0 | -------- | 65.5 | 58.0 | |
| Nov. 8 | 1 p. m. | 20.0 | 68.0 | 67.0 | 71.5 | |
| Nov. 8 | 6 p. m. | 20.8 | 68.0 | 68.0 | 71.5 | |
| Nov. 9 | 8 p. m. | 18.0 | 70.0 | 68.0 | 62.5 | Fermenting vigorously. |
| Nov. 9 | 1 p. m. | 16.0 | 80.5 | 80.5 | 66.0 | |
| Nov. 9 | 6 p. m. | 10.0 | 84.0 | 82.5 | 68.0 | |
| Nov. 10 | 8 a. m. | 4.5 | -------- | 91.5 | 57.0 | |
| Nov. 10 | 1 p. m. | 1.5 | 100.5 | 98.5 | 70.0 | |
| Nov. 10 | 5:30 p. m. | .5 | 100.5 | 100.5 | -------- | |
| Nov. 11 | 8 a. m. | 0 | 95.0 | 97.0 | -------- | Drew off into cask 2. |

TABLE No. 43.

*Fermentation VII. Petite Sirah from Acampo, Vat No. 7; sulfite, 8 ounces per ton; pure yeast.*

| Date. | Hour. | Balling per cent. | Temperature. | | | Remarks. |
|---|---|---|---|---|---|---|
| | | | Cap. | Bottom. | Room. | |
| Nov. 4 | 1 p. m. | 21.0 | -------- | -------- | -------- | Started to fill vat and added 4 pounds sulfite. |
| Nov. 4 | 5 p. m. | -------- | -------- | -------- | -------- | Finished filling gradually. |
| Nov. 5 | 9 a. m. | 22.5 | -------- | 59.0 | 61.0 | |
| Nov. 5 | 1:30 p. m. | -------- | -------- | -------- | 63.5 | Added 30 gallons of yeast. |
| Nov. 5 | 6 p. m. | 22.4 | -------- | 62.5 | 71.0 | |
| Nov. 6 | 8 a. m. | -------- | 67 | -------- | 60.0 | Fermentation started. |
| Nov. 6 | 1 p. m. | 21.0 | 86.0 | 64.5 | 70.0 | Fermenting well. |
| Nov. 6 | 6 p. m. | 20.0 | -------- | 73.5 | 73.5 | Fermentation vigorous. |
| Nov. 7 | 8 a. m. | 13.0 | 96.0 | 88.5 | 58.0 | |
| Nov. 7 | 1 p. m. | 6.0 | 100.5 | 97.0 | 75.0 | |
| Nov. 7 | 6 p. m. | 1.75 | 100.5 | 97.0 | 71.5 | |
| Nov. 8 | 8 a. m. | 0 | -------- | 98.5 | 70.0 | |
| Nov. 8 | 9 a. m. | -------- | -------- | -------- | -------- | Drew off free run into cask 16. |

TABLE No. 44.

*Fermentation VIII. Petite Sirah from Acampo, Vat No. 10; sulfite, 12 ounces per ton; pure yeast.*

| Date. | Hour. | Balling per cent. | Temperature. | | | Remarks. |
|---|---|---|---|---|---|---|
| | | | Cap. | Bottom. | Room. | |
| Nov. 7 | 1:30 p. m. | -------- | -------- | -------- | -------- | Began filling vat and adding sulfite gradually. |
| Nov. 7 | 5:20 p. m. | -------- | -------- | -------- | -------- | |
| Nov. 8 | 8 a. m. | 21 | -------- | 66.0 | 58.0 | Vat full. |
| Nov. 8 | 6 p. m. | 21.75 | -------- | 71.5 | 75.0 | Added pure yeast. |
| Nov. 9 | 8 a. m. | 21 | -------- | 68.0 | 62.5 | Fermentation starting. |
| Nov. 9 | 1 p. m. | 16 | -------- | 84.0 | 66.0 | Fermentation vigorous. |
| Nov. 9 | 6 p. m. | 10.5 | 89.5 | 83.5 | 68.0 | |
| Nov. 10 | 8 a. m. | 4 | 97.0 | 97.0 | 57.0 | |
| Nov. 10 | 1 p. m. | 1.5 | 102.0 | 98.5 | 70.0 | |
| Nov. 10 | 5:30 p. m. | .25 | 102.0 | 98.5 | 68.0 | Drew off into cask 16. |

TABLE No. 45.

*Summary of Fermentations VI, VII and VIII.*

| | Balling per cent. | Temp. | Sulfite. | Pure yeast. | Fermentation. | | | Sugar lost per 24 hours. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Commenced. | Lasted. | Total. | A From filling. | B From starter. | C From visible fermentation. |
| VI ----- | 21 | 72.5 | 0 | 0 | 36 hrs. | 74 hrs. | 110 hrs. | 4.58 | 4.58 | 6.80 |
| VII ----- | 22.5 | 59 | 8 oz. | 18 hrs. | 25 hrs. | 62 hrs. | 87 hrs. | 6.21 | 7.83 | 8.71 |
| VIII ----- | 21.0 | 66 | 12 oz. | 15 hrs. | 25 hrs. | 55 hrs. | 80 hrs. | 6.30 | 7.76 | 9.17 |

The results shown in Table 45 confirm the conclusions drawn from those of Table 41. Column A shows a net gain of over 35 per cent in the rapidity with which the sugar disappears, in favor of the vats receiving sulfite and pure yeast. This indicates, as in the previous experiments, that a delay of eighteen hours, due to sulfiting, is more than compensated for by the gain in time, due to the addition of a starter after that delay.

The gain, due to the starter alone, as indicated by column B, is about 70 per cent. Column C shows that the pure yeast fermented about 32 per cent faster in the sulfited must than the mixed natural yeasts did in the unsulfited.

The character of the three fermentations is shown graphically in diagram 11. Both the sulfited vats finished their fermentation before the witness, although the grapes were much colder when crushed. No. VIII finished before No. VII, because the grapes were warmer and not quite so sweet. There is no evidence that the larger amount of sulfite delayed the fermentation at all.

All three fermentations continued until the Balling saccharometer indicated 0. If the weather had been warm, it is very probable that the unsulfited vat would have failed to finish.

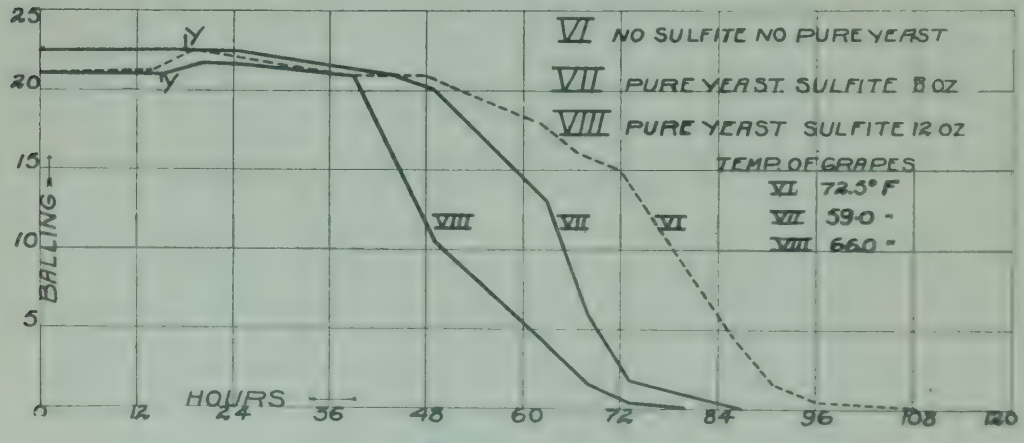



DIAGRAM 11.

Fermentation curves of Petite Sirah; VI, VII, VIII.

TABLE No. 46.

*Fermentation IX. Zinfandel from Contra Costa County, Vat No. 20, ordinary fermentation, no sulfite, no starter.*

| Date. | Hour. | Balling per cent. | Temperature. | | | Remarks. |
|---|---|---|---|---|---|---|
| | | | Cap. | Bottom. | Room. | |
| Oct. 23 | 10 a. m. | 24.5 | | | | Good condition; good many raisins (first load). |
| Oct. 24 | | | | | | Second load; reduced sugar. |
| Oct. 25 | | | | | | 1½ loads; fermentation vigorous. |
| Oct. 25 | 6 p. m. | 22.0 | | 73.5 | 72.0 | |
| Oct. 26 | 8 a. m. | 19.0 | | 75.0 | 60.0 | |
| Oct. 26 | 11 a. m. | 17.0 | 81 | 79.0 | 64.0 | |
| Oct. 26 | 6 p. m. | 14.5 | 86 | 84.0 | 65.0 | |
| Oct. 27 | 8 a. m. | 6.0 | 97 | 95.0 | 59.0 | |
| Oct. 27 | 11:30 a. m. | 4.5 | | | | Drew off 2 puncheons; rest of record refers to wine in puncheons. |
| Oct. 27 | 6 p. m. | 3.5 | | | | |
| Oct. 28 | 6 p. m. | 1.0 | | | | |
| Oct. 30 | 8 a. m. | .25 | | | | |
| Nov. 4 | | 0 | | | | |

TABLE No. 47.

*Fermentation X. Zinfandel from Contra Costa County, Vat No. 8; sulfite 12 ounces; pure yeast.*

| Date. | Hour. | Balling per cent. | Temperature. | | | Remarks. |
|---|---|---|---|---|---|---|
| | | | Cap. | Bottom. | Room. | |
| Oct. 4 | 4 p. m. | 24 | | | | First load crushed; added 2 pounds of sulfite. |
| Oct. 5 | 2 p. m. | | | | | Second load crushed; added 2 pounds of sulfite. |
| Oct. 5 | 5 p. m. | | | | | Third load crushed; added 1 pound of sulfite. |
| Oct. 6 | 10:30 p. m. | 23.8 | | | | Fourth load crushed; added 2 pounds of sulfite. |
| Oct. 6 | 2 p. m. | | | | | Added 2 pounds sulfite. |
| Oct. 6 | 5:15 p. m. | | | | | Finished filling and added 2 pounds sulfite. Reduced sugar. |
| Oct. 6 | 6 p. m. | 22.3 | | 68 | 73 | Added pure yeast. |
| Oct. 7 | 7:30 a. m. | 22 | | 70 | 60 | |
| Oct. 7 | 6 p. m. | 21 | | 70 | 70 | Fermenting. |
| Oct. 8 | 8 a. m. | 19.3 | 80 | 73 | 58 | |
| Oct. 8 | 1 p. m. | 15 | | 83 | 75 | Very active. |
| Oct. 8 | 6 p. m. | 11 | | 86 | 72 | |
| Oct. 9 | 8 a. m. | 3 | | 99 | 70 | |
| Oct. 9 | 12 m. | 2 | | 100 | 66 | |
| Oct. 9 | 5 p. m. | 0 | 100 | 98.5 | 68 | Drew off. |

TABLE No. 48.

*Fermentation XI. Zinfandel from Contra Costa County, Vat No. 11; sulfite, 12 ounces; pure yeast.*

| Date. | Hour. | Balling per cent. | Temperature. | | | Remarks. |
|---|---|---|---|---|---|---|
| | | | Cap. | Bottom. | Room. | |
| Oct. 9 | 10 a. m. | ---- | ---- | ---- | ---- | Began crushing; 2½ pounds sulfite added gradually. |
| Oct. 10 | ---- ---- | ---- | ---- | ---- | ---- | Continued crushing; three pounds sulfite added gradually. |
| Oct. 11 | ---- ---- | ---- | ---- | ---- | ---- | Continued crushing; two pounds sulfite added gradually. |
| Oct. 11 | 3:30 a. m. | ---- | ---- | ---- | ---- | Finished crushing; many raisins. |
| Oct. 11 | 6 p. m. | 23.5 | ---- | ---- | ---- | Reduced sugar and added pure yeast. |
| Oct. 12 | 8 a. m. | 22 | ---- | 64 | 61 | |
| Oct. 12 | 1 p. m. | 21.8 | ---- | 70 | 67 | Fermentation started. |
| Oct. 12 | 6 p. m. | 20.5 | ---- | 69 | 74 | |
| Oct. 13 | 8 a. m. | 18 | 75 | 74 | 61 | Fermenting actively. |
| Oct. 13 | 2 p. m. | 15 | ---- | ---- | 71 | |
| Oct. 13 | 6 p. m. | 11.5 | 84 | 83 | 68 | |
| Oct. 14 | 8 a. m. | 6 | ---- | 97 | 63 | |
| Oct. 14 | 1 p. m. | 4 | 99 | 97 | 73 | |
| Oct. 14 | 6 p. m. | 2.5 | ---- | 99 | 77 | |
| Oct. 15 | 8 a. m. | 0 | ---- | 99.5 | 58 | Drew off. |

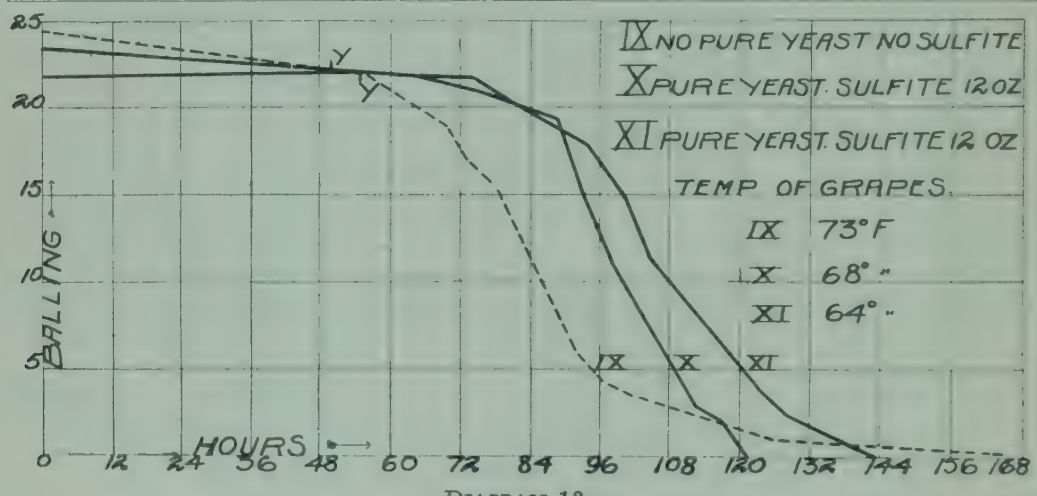

IX NO PURE YEAST NO SULFITE
X PURE YEAST SULFITE 12 OZ
XI PURE YEAST SULFITE 12 OZ
TEMP OF GRAPES.
IX 73° F
X 68° "
XI 64° "
BALLING
HOURS
0 12 24 36 48 60 72 84 96 108 120 132 144 156 168
5 10 15 20 25

DIAGRAM 12.

Fermentation curves—Zinfandel from Contra Costa County.

The grapes used in this series were in good condition, clean and none moldy. They were thoroughly ripe and included a few raisins. The vats were filled gradually as the loads arrived, about fifty hours elapsing between the commencement and the end of filling. The sulfited vats were prevented from fermenting until the filling was complete. The unsulfited vat commenced to ferment vigorously before the last loads were crushed. The violent fermentation of the sulfited vats, therefore, took place fifteen or twenty hours later than that of the witness vat. In spite of this delay the sulfited vats became dry sooner.

In neither of the sulfited vats was there any perceptible fermentation before the addition of the starter of pure yeast. This shows the practicability of delaying fermentation of crushed grapes forty-eight hours by the use of sulfite, and their perfect subsequent fermentation by means of pure yeast. Where grapes have to be transported long distances from the vineyard to the cellar, it would undoubtedly be better to crush and sulfite them at the vineyard and transport them in this condition to the winery. The activities of molds and vinegar bacteria, so injurious to wine grapes transported in the usual way in flat cars or boxes, would thus be prevented.

Records similar to the foregoing were kept on all the red wine fermentations with similar results. All showed the prompt start and quicker finish, due to the addition of pure yeast. They showed also that sulfites in the amounts used did not delay the fermentation appreciably, and were of no value in preventing hot fermentations, though they may and, in fact, do in many cases prevent some of the worst consequences of hot fermentations by discouraging the growth of bacteria.

3. WHITE WINE FERMENTATIONS.—Observations were made on the following white wine fermentations:

| Variety and origin of grapes. | Sulfite per ton. | Pure yeast. | Fermenting vessel. |
|---|---|---|---|
| I. Green Hungarian from Acampo | 0 | 0 | puncheon No. 1 |
| II. Green Hungarian from Acampo | 0 | 0 | puncheon No. 8 |
| III. Green Hungarian from Acampo | 0 | 0 | puncheon No. 9 |
| IV. Green Hungarian from Acampo | 12 oz. | 0 | puncheon No. 4 |
| V. Green Hungarian from Acampo | 12 oz. | plus | puncheon No. 2 |
| VI. Green Hungarian from Acampo | 12 oz. | plus | puncheon No. 3 |
| VII. Green Hungarian from Acampo | 12 oz. | plus | puncheon No. 6 |
| VIII. Green Hungarian from Acampo | 12 oz. | plus | puncheon No. 7 |
| IX. Green Hungarian from Acampo | 12 oz. | plus | 1500-gal. cask No. 7 |
| X. Palomino from Acampo | 0 | 0 | puncheon No. 12 |
| XI. Palomino from Acampo | 32 oz. | plus | puncheon No. 13 |
| XII. Palomino from Acampo | 32 oz. | plus | puncheon No. 14 |

A series of 8 puncheons was filled with the free run must of a carload of Green Hungarian grapes from Acampo. The grapes were in rather poor condition, for, being very juicy and thin skinned, many were broken, and the natural micro-organisms were present in large numbers.

Three puncheons (fermentations I, II, and III) were filled with the must and allowed to ferment spontaneously without any addition. One puncheon (IV) was sulfited at the rate of 12 ounces of metabisulfite to 200 gallons and allowed to ferment without a starter. The other four puncheons (V, VI, VII, and VIII) were sulfited in the same way, but after settling for forty-eight hours, were drawn off the sediment into clean puncheons and started with pure yeast. A larger lot of the same must was defecated in the same way in a 1,700 gallon vat and, after settling, drawn off into a 1,500 gallon cask and fermented with pure yeast.

The following partial records show the progress of some of the fermentations.

TABLE No. 49.

*Green Hungarian. No sulfite. No pure yeast.*

| Fermentation I. | | | Fermentation II.* | | | Fermentation III. | | |
|---|---|---|---|---|---|---|---|---|
| Hours. | Balling. | Temp. | Hours. | Balling. | Temp. | Hours. | Balling. | Temp. |
| 0 | 20 | 66 | 0 | | | 0 | 20 | |
| 30 | 17 | 66 | 24 | 18 | 64.5 | 48 | 10 | 70 |
| 44 | 10 | 73.5 | 34 | 16 | | 52 | 7.8 | 72.5 |
| 54 | 3.7 | 82.5 | 46 | 10 | 74.5 | 55 | 5.3 | |
| 68 | 0 | 79.5 | 50 | 7.5 | 75.0 | 72 | 0 | 78 |

*Record incomplete.

TABLE No. 50.

*Green Hungarian.*

| Fermentation IV. Sulfite 12 ounces. No pure yeast. | | | Fermentation V. Sulfite 12 ounces. Pure yeast. | | | Fermentation IX. 1500-gallon cask. Sulfite 12 ounces. Pure yeast. | | |
|---|---|---|---|---|---|---|---|---|
| Hours. | Balling. | Temp. | Hours. | Balling. | Temp. | Hours. | Balling. | Temp. |
| 0 | 20.0 | | 0 | 19.6 | 59.0 | 0 | 21 | 61.5 |
| 72 | 20.0 | | 18 | 19.2 | 61.0 | 40 | 20 | |
| 90 | 17.0 | 62.5 | 28 | 18.0 | 63.5 | 136 | 19.7 | |
| 112 | 16.0 | 61.0 | 42 | 16.0 | 65.5 | 160 | 17.0 | 68.0 |
| 140 | 15.2 | 63.5 | 50 | 14.0 | 66.5 | 170 | 15.5 | 73.5 |
| 146 | 13.0 | 65.0 | 64 | 9.8 | 72.5 | 194 | 10.0 | 80.5 |
| 160 | 7.5 | 71.5 | 69 | 7.5 | 78.0 | 199 | 6.5 | 83.0 |
| 165 | 5.2 | 74.5 | 88 | 4.0 | 77.0 | 218 | 4.0 | 86.0 |
| 170 | 4.5 | 76.0 | 93 | 2.5 | 77.0 | 228 | 3.0 | 88.0 |
| 189 | 0 | 79.0 | 98 | 2.0 | 76.0 | 10 days. | 2.5 | 81.0* |
| | | | 112 | .5 | 73.5 | 21 days. | 2.0 | 72.5† |
| | | | 117 | 0 | 73.5 | 22 days. | 1.5 | |
| | | | | | | 24 days. | 1.0 | |
| | | | | | | 26 days. | .5 | |
| | | | | | | 31 days. | 0 | |

*Pumped over to aerate.
†New yeast added.

TABLE No. 51.

*Green Hungarian. Sulfite, 12 ounces, and pure yeast.*

| Fermentation VI. | | | Fermentation VII. | | | Fermentation VIII. | | |
|---|---|---|---|---|---|---|---|---|
| Hours. | Balling. | Temp. | Hours. | Balling. | Temp. | Hours. | Balling. | Temp. |
| 0 | 18.6 | 61.5 | 0 | 19.1 | 62.5 | 0 | 18.1 | 62.5 |
| 21 | 18.4 | 59.0 | 15 | 19.1 | 59.0 | 16 | 17.9 | 61.5 |
| 45 | 18.4 | 62.0 | 25 | 18.5 | 61.5 | 40 | 17.5 | 61.5 |
| 69 | 18.2 | 62.0 | 49 | 18.0 | 62.5 | 64 | 17.5 | 62.5 |
| 93 | 18.0 | 64.5 | 63 | 17.0 | 62.5 | 74 | 16.0 | 68.0 |
| 117 | 17.5 | 66.0 | 67 | 16.5 | 69.0 | 88 | 15.0 | 68.0 |
| 141 | 15.0 | 66.0 | 71 | 16.0 | 68.0 | 98 | 13.25 | 68.0 |
| 151 | 12.5 | 70.0 | 85 | 14.0 | 68.0 | 112 | 10.5 | 70.0 |
| 165 | 9.0 | 73.5 | 95 | 12.0 | 69.0 | 122 | 10.0 | |
| 175 | 6.2 | 77.0 | 109 | 10.0 | 68.0 | 136 | 6.0 | 70.0 |
| 189 | 3.7 | 74.5 | 119 | 7.5 | 70.0 | 160 | 3.5 | 73.5 |
| 199 | 2.0 | 74.5 | 133 | 5.5 | 70.5 | 184 | 2.0 | 72.5 |
| 223 | 0 | 75 | 157 | 3.0 | 71.5 | 208 | 1.0 | 70.5 |
| | | | 181 | 2.0 | 70.0 | 232 | 0 | 70.0 |
| | | | 205 | 1.0 | 69.0 | | | |
| | | | 215 | 0 | 71.5 | | | |

The curves of several typical examples of these fermentations are shown in diagram 13.

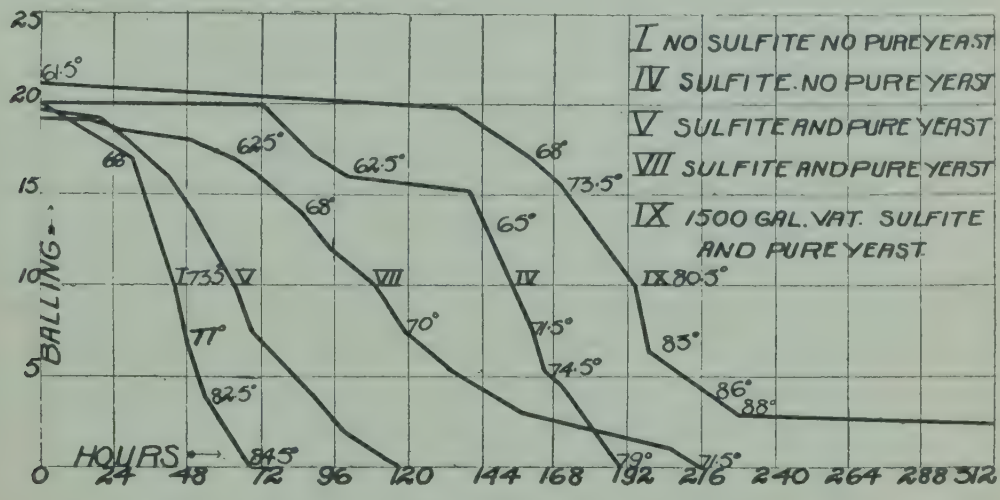



DIAGRAM 13.

Fermentation Curves of Green Hungarian.

These show a notable lengthening of the fermentation in the casks where sulfite was used. This is in strong contrast with the results of the red wine fermentations where it was found that the slight retarding influence of the $SO_2$ was much exceeded by the acceleration due to the use of a starter.

In No. I, in which fermentation was allowed to start spontaneously and without $SO_2$, the Balling per cent had fallen to 0 in less than 3 days. This showed the presence of a large amount of natural yeast due to the bad condition of the grapes. In No. IV, which received an addition of sulfite, the start of fermentation was delayed for several days. The actual tumultuous fermentation, however, was almost as rapid as that of No. I, but the total time needed before reaching 0 Balling was over 8 days. The irregularity of the curve of this fermentation is unaccounted for, but may have been due to the presence of a mixture of fermentative organisms having different degrees of resistance to $SO_2$ and to alcohol.

Nos. V, VII, and IX were treated with sulfite, defecated, drawn off the sediment and started with pure yeast. The regularity of Nos. V and VII is in marked contrast with No. IV and is doubtless due to the uniformity of the yeast. The retarding influence of the $SO_2$ is very marked in No. VII but much less so in No. V. This seems to be due to the fact that in No. VII the yeast was added 49 hours after the sulfite and in No. V 68 hours. The earlier addition of the yeast exposed it to larger amounts of free $SO_2$ and thus weakened its fermenting power. No ill effect resulted from this slackening of the fermentation as both

musts became perfectly dry without interruption. The slower fermentation of No. VII in fact resulted in a lower maximum temperature than in No. II, which is an advantage. Sulfurous acid thus seems to be capable of controlling the temperature to some extent in white wine fermentation, contrary to the results shown in the red wine fermentations where no appreciable effect of this kind was noted.

In No. IX the yeast was added only 30 hours after the sulfite and we have a correspondingly greater delay in the fermentation. The delay in this case did not result in a lower maximum temperature on account of the large volume of fermenting must (1500 gallons) which retarded the escape of heat. Fermentation in No. IX did not start perceptibly until over 5 days after the addition of the yeast, while in the sulfited musts in puncheons it was noticeable in from 24 to 48 hours. The fermentation after it started was rapid, owing to the conservation of the heat. It became very slow, however, by the ninth day while the saccharometer still showed 3 per cent Balling. By the tenth day the sugar had fallen only 2.5 per cent Balling. A thorough aeration on this day stimulated the fermentation slightly but on the twenty-first day 2 per cent Balling still remained; only .5 per cent Balling having been eliminated in 8 days.

It was evident that the yeast was weak so that on this day a new addition of pure yeast was made. The fermentation revived and one and a half per cent of sugar disappeared in 5 days. The wine finally reached 0 per cent Balling on the thirty-first day.

The length of this fermentation was due in the first place to the use of more sulfurous acid than was necessary for the grapes, which only had 21 per cent Balling and for the low temperature of the must which was 61.5° F. at the start. In No. V, where sufficient time was allowed for the $SO_2$ to combine before adding the yeast, no harm was done. In No. VII, where the must was placed in a puncheon, there was sufficient aeration to keep the fermentation going. In No. IX, however, the yeast was added too soon and the large size of the fermenting cask diminished the amount of aeration, resulting in a deficiency of oxygen for the yeast and a slower disappearance of the free $SO_2$.

All these cellar tests corroborate the conclusion drawn from the laboratory tests reported in Part II that the effect of sulfurous acid is due almost entirely to the free $SO_2$, and that the $SO_2$ remains free longer and in larger amounts in must alone than in the whole mass of crushed grapes. Contrary to the usual practice, therefore, more sulfurous acid is needed and should be used in red wine fermentations than in white.

In fermentation X, XI, and XII the effect of very large doses of $SO_2$ on excessively moldy grapes was tried. The results were not favor-

able. All the good effects of sulfurous acid were obtained with small doses, and large doses simply delay the fermentation without any corresponding advantage and very large doses injure the flavor of the wine.

In a general way, the conclusion is that for the conditions under which our tests were made, for grapes of moderate sugar contents and in cool weather about 8 ounces to 12 ounces of potassium metabisulfite per ton give the best results in the fermentation of red wine, and about half of this amount is all that is needed in the defecation and fermentation of white wine.

These comparatively small amounts are sufficient to paralyze immediately all the micro-organisms present, which is the main object, and then quickly change to the combined form so that they do not interfere with the work of the yeast which is added later. Where moderation of the rate and temperature of fermentation are desirable they should be obtained by cooling methods and not by the addition of excessively large doses of $SO_2$.

(d) *Quality of the Wines.*—In estimating the influence of the character of the fermentation on the quality of the wine, we must take into consideration the data supplied by tasting, chemical analysis and microscopical examination. These are all necessary to determine how well the yeast has done its work, how well the work of injurious micro-organisms has been controlled and what the probable future development of the wine will be.

1. SUGAR. Owing to the coolness of the season there was very little trouble in fermenting the wines down to dryness. What little difficulties were encountered show clearly the utility of the proper use of sulfurous acid in this respect. Wine in five of the storage casks showed appreciable amounts of unfermented sugar when analyzed on February 3, 1912.

TABLE No. 52.

*Wines showing unfermented sugar.*

| Wines. | Sugar, per cent. | | | Vol. acid. |
|---|---|---|---|---|
| | Dec. 16. | Feb. 3. | April 10. | |
| I, II. Zinfandel, no sulfite, no yeast | .63 | .65 | ---- | .140 |
| X, XI. Zinfandel, sulfite 12 ounces, plus yeast | ---- | .34 | ---- | .078 |
| XV. Barbera, sulfite 5 ounces, no yeast | 1.60 | 1.60 | .7 | .075 |
| IX. Green Hungarian, sulfite 12 ounces, plus yeast | ---- | .31 | .3 | .074 |
| XI. Palomino, sulfite 36 ounces, plus yeast | ---- | 1.19 | ---- | .120 |

The Zinfandel of fermentations I and II which was fermented in the usual manner without sulfite or pure yeast showed .63 per cent of

unfermented sugar. This would not have been serious if the wine had been sound, but the volatile acid had increased to .14 per cent and a microscopical examination showed very large numbers of long rod-shaped bacteria. Such a wine as this, if left to itself, is sure to spoil completely during the first warm weather of spring.

The Zinfandel of fermentations X and XI which had been sulfited and fermented with pure yeast, showed .34 per cent of unfermented sugar. The volatile acid, however, was normal at .078 per cent and the microscope showed yeast cells of uniform appearance with only an occasional bacterial rod. Such a wine can be safely handled by the ordinary cellar methods and will ferment prefectly dry during the spring.

The Barbera, fermentation XV, which was sulfited lightly, but allowed to ferment with its own yeast showed 1.6 per cent of sugar on February 3d. The volatile acid was normal. The microscope revealed many yeast cells of various forms—ellipsoideus, pastorianus, and apiculatus types and a few bacteria. By April 10th the sugar had fallen to .7 per cent and there was every indication that the wine would ferment to dryness and remain sound.

The Green Hungarian, white fermentation IX, in 1,500 gallon cask, had been defecated with 12 ounces of metabisulfite and fermented with pure yeast. The fermentation had been very long and on February 3d the wine still showed .3 per cent of unfermented sugar, but the volatile acid was quite normal, .074 per cent. The microscope showed the sediment to be almost entirely composd of yeast cells, only a very few bacteria being found. This wine was cloudy and inferior to that fermented in puncheons but will undoubtedly finally become dry and clear and is in no danger of spoiling.

The Palomino, white fermentation XI, was made from extremely defective grapes, crushed, moldy and smelling of vinegar. The yeast was evidently injured by the large quantity of sulfite used, and the sulfited wine still showed 1.19 per cent of sugar when a puncheon of the same must fermented without sulfite was practically dry. The sediment showed an abundance of yeast and very few bacteria, so that there is no doubt that the wine will complete its fermentation in time. The comparatively high volatile acidity, .12 per cent, is probably caused by abnormal work of the yeast due to its weakened condition. This high volatile acidity does not indicate any danger of spoiling as it would if caused by bacteria, and the wine is in no danger of becoming unsound. A much smaller amount of sulfite, however, would undoubtedly have given better results without causing the "sulfur" taste which the wine still shows.

2. VOLATILE ACIDITY. In Tables 53 and 54 are given the various determinations of the volatile acidity of the wines made at intervals from a few days after the completion of fermentation until six months after.

TABLE No. 53.

*Progress of volatile acidity.*

| Red Wines. | Volatile acid, per cent. | | | | | |
|---|---|---|---|---|---|---|
| | Oct. 16. | Oct. 18. | Nov. 14. | Dec. 16. | Feb. 3. | April 10. |
| I, II. Zinfandel; no sulfite, no yeast | .073 | .105 | .112 | .115 | .140 | -------- |
| III. Zinfandel; sulfite 5 ounces | -------- | .096 | .092 | -------- | .089 | -------- |
| IV, V. Zinfandel; sulfite 12 ounces plus yeast | .076 | .086 | .082 | .082 | .080 | -------- |
| VI. Petite Sirah; no sulfite, no yeast | -------- | .088 | .084 | .080 | .077 | .114 |
| VII, VIII. Petite Sirah; sulfite 10 ounces plus yeast | .055 | .076 | .076 | .078 | .078 | .073 |
| IX. Zinfandel; no sulfite, no yeast* | -------- | -------- | .061 | .082 | .079 | .081 |
| X, XI. Zinfandel; sulfite 12 ounces plus yeast | .064 | .080 | -------- | .082 | .078 | .078 |
| XII, XIII. Bouschet; sulfite 8 ounces plus yeast | -------- | -------- | -------- | .074 | .070 | .096 |
| XV. Barbera; sulfite 5 ounces | -------- | -------- | -------- | .061 | .059 | .075 |

* This wine was stored in 180-gallon puncheons. All the others in 1500- to 3500-gallon casks.

TABLE No. 54.

*Progress of volatile acidity.*

| White Wines. | Volatile acid, per cent. | | | |
|---|---|---|---|---|
| | Nov. 6. | Dec. 16. | Feb. 3. | April 10. |
| I. Green Hungarian; no sulfite, no yeast | .064 | .066 | .065 | -------- |
| III. Green Hungarian; no sulfite, no yeast | .070 | .073 | .071 | .072 |
| IV. Green Hungarian; sulfite 12 ounces, no yeast | .048 | .070 | .065 | -------- |
| V. Green Hungarian; sulfite 12 ounces plus yeast | .064 | .079 | .076 | .076 |
| VII. Green Hungarian; sulfite 12 ounces plus yeast | .065 | .066 | .075 | .065 |
| VIII. Green Hungarian; sulfite 12 ounces plus yeast | .061 | .064 | .068 | .066 |
| IX. Green Hungarian; sulfite 12 ounces plus yeast* | .061 | .066 | .067 | .074 |
| X. Palomino; no sulfite, no yeast | -------- | .068 | .065 | .065 |
| XI. Palomino; sulfite 36 ounces plus yeast | -------- | .100 | .100 | .120 |
| XII. Palomino; sulfite 36 ounces plus yeast | -------- | .080 | .090 | .102 |

*This wine was stored in a 1500-gallon cask. All the others in 180-gallon puncheons.

As shown by Table 53 the volatile acidity in all the sulfited red wines was normal, showing a clean fermentation and absence of bacterial action. In one wine, Zinfandel I and II, fermented in the ordinary way without sulfites, the volatile acidity commenced to rise almost immediately after the end of the tumultuous fermentation and continued so long as the observations extended. This is a case of a "stuck" wine and shows the ordinary course of a young wine containing a remnant of unfermented sugar and large quantities of bacteria.

In the Petite Sirah No. VI, also an ordinary fermentation, the volatile acidity remained normal for about four months following the vintage. During the first warm weather of spring, however, the volatile acid commenced to rise and by April 10th it was 60 per cent higher than that of Petite Sirah VII and VIII fermented with sulfite and pure yeast. In this case the ordinary fermentation and that in which sulfite was used were successfully brought to 0 Balling and the wines were both practically dry when analyzed. The sulfited wine showed, under the microscope, a clean sediment with very few bacteria, while the unsulfited showed large numbers of bacteria almost from the beginning. In April these bacteria were very numerous. They consisted of long and short rods and were not vinegar bacteria. This experiment shows that even the completion of the fermentation to apparent dryness does not always prevent the increase of volatile acid in unsulfited wines.

The remaining unsulfited wine, Zinfandel No. IX shows a perfectly normal volatile acidity up to April 10th, being in this respect practically identical with the sulfited Zinfandel Nos. X, XI made from the same grapes. When analyzed on February 3d it showed only .21 per cent of unfermented sugar while the sulfited wine showed .34 per cent at the same date. A microscopical examination of the sediment showed very few bacteria in the sulfited wine but a larger number in the unsulfited.

Both wines were prefectly sound and if handled properly were in no danger of deteriorating. That this wine No. IX kept better than the others fermented in the same way without sulfiting seems to be due to the fact that it was stored in puncheons immediately after fermentation. This view is corroborated by the fact that there was no abnormal increase of the volatile acid in any of the Green Hungarian wines stored in puncheons whether sulfite was used or not. The increase of volatile acidity after fermentation is due to anaerobic bacteria which grow the more vigorously the better they are protected from oxygen. In a puncheon, the aeration through the pores of the wood is much greater than in a large vat. In a puncheon of 180 gallons the ratio of the surface to the volume is about $4\frac{1}{2}$ times greater than in a cask of 1500 gallons. Supposing the wood of both casks to be of the same kind and thickness, therefore, the wine in a puncheon is aerated by the slow penetration of air through the staves and head $4\frac{1}{2}$ times as much as the wine in a 1500 gallon cask. This is sufficient to account for the quicker finish of the fermentation of wines stored in small casks, the smaller growth of anaerobic bacteria and the better development of the wine. The use of sulfurous acid prevents the excessive growth of bacteria even in the large casks, but it does not overcome the slowness of the after fermentation or of the development of the wine.

3. FIXED ACIDITY. The influence of sulfite and pure yeast on the fixed acidity is masked in the red wines by unavoidable variations in the grapes and by the difficulty of obtaining a representative sample before fermentation. The errors thus introduced are likely to neutralize each other to some extent in the means of all the wines. The figures representing the average acidity found in the red grapes and in the corresponding red wines may safely be taken as representing the general direction of the influence in this respect. In the white wines the observational errors are much smaller. The white grapes were all crushed into the same vat and the must from this vat distributed into the various vats and puncheons in which the experiments were made. The variations in the composition of the raw material and in the samples taken for analysis are much less in this case.

TABLE No. 55.

*Influence of sulfurous acid on fixed acidity.*

| | Alcohol. | Fixed acid. | | | |
|---|---|---|---|---|---|
| | | No sulfite. | | Sulfite. | |
| | | Must. | Wine. | Must. | Wine. |
| RED WINES. | | | | | |
| Zinfandel, I, II | 11.85 | 1.06 | .51 | | |
| Zinfandel, III; 5 ounces sulfite | 12.60 | | | 1.00 | .38 |
| Zinfandel, IV, V; 12 ounces sulfite | 12.30 | | | .97 | .63 |
| Petite Sirah, VI | 11.65 | .81 | .40 | | |
| Petite Sirah, VII, VIII; 10 ounces | 11.90 | | | .84 | .36 |
| Zinfandel, IX | 13.40 | .95 | .53 | | |
| Zinfandel, X, XI, 12 ounces | 12.15 | | | .96 | .82 |
| Average fixed acidity of red wines | | .94 | .48 | .94 | .55 |
| WHITE WINES. | | | | | |
| Green Hungarian, I | 11.30 | .64 | .45 | | |
| Green Hungarian, III | 11.30 | .64 | .43 | | |
| Green Hungarian, IV; 12 ounces sulfite | 11.25 | | | .64 | .57 |
| Green Hungarian, V; 12 ounces sulfite | 11.20 | | | .64 | .60 |
| Green Hungarian, VII; 12 ounces sulfite | 11.30 | | | .64 | .60 |
| Green Hungarian, VIII; 12 ounces sulfite | 11.30 | | | .64 | .55 |
| Green Hungarian, IX; 12 ounces sulfite | 11.20 | | | .64 | .51 |
| Average fixed acidity of white wines | | .64 | .44 | .64 | .57 |

This table indicates that in the red wine fermentations where no sulfite was used, there was a loss of 49 per cent of the fixed acidity. This loss was reduced to 41 per cent where sulfites were used. In the white wine only 31 per cent of the fixed acidity was lost even in the ordinary fermentations, and this loss was reduced by the use of sulfites to 11 per cent.

The greater loss of fixed acidity in the red wines is accounted for principally by the more advanced stage of maturity of the grapes from which they were made. The less ripe the grapes the more of their

acidity exists in the form of free tartaric acid. This acid is soluble in all proportions in the wine and, therefore, is found *in toto* in the wine unless destroyed by acid-consuming organisms. In the riper grapes, a greater part of the acidity exists in the form of bitartrate of potash which is less soluble in the wine than in the must. A certain proportion of this acidity is therefore lost from the wine by the precipitation of cream of tartar. This loss is further increased by the production of alcohol in which the bitartrate is insoluble. The more alcoholic the wine, therefore, the less bitartrate can remain in solution.

The increase of acidity with the use of sulfurous acid is due, therefore, principally to its conservation of the free acid.

4. ALCOHOL. As shown by Table 56 the sulfited red wines showed a better utilization of the sugar. The ratio of the alcohol by volume in the wine to the original Balling ° of the must being on the average .55 for the sulfited wines and .52 for the parallel wines fermented without sulfites.

TABLE No. 56.

*Influence of $SO_2$ and pure yeast on alcohol production in red wines.*

| Fermentation. | No sulfites. | | | Sulfites. | | |
|---|---|---|---|---|---|---|
| | Balling ° of must. | Alcohol in wine. | Ratio. | Balling ° of must. | Alcohol in wine. | Ratio. |
| Zinfandel, I, II | 24.8 | 11.85 | .48 | | | |
| Zinfandel, III | | | | 22.3 | 12.60 | .57 |
| Zinfandel, IV, V | | | | 22.5 | 12.40 | .55 |
| Petite Sirah, VI | 22.5 | 11.85 | .53 | | | |
| Petite Sirah, VII, VIII | | | | 22.1 | 11.85 | .54 |
| Zinfandel, IX | 24.5 | 13.40 | .55 | | | |
| Means | 23.8 | 12.37 | .52 | 22.3 | 12.28 | .55 |
| Theoretical ratio | 23.8 | 13.57 | .57 | 22.3 | 12.49 | .56 |

The ratio of alcohol to Balling ° should be higher with the grapes containing more sugar, as the proportion of non-sugar extract included in the Balling ° is less. In the last line of the table is given the amount of alcohol and the ratio which should have been obtained according to Salleron's tables. This shows an average loss of alcohol in the unsulfited wines of 1.2 per cent and in the sulfited of only .21 per cent. These losses represent partly, unfermented sugar, and partly, sugar and alcohol wasted by wild yeasts, bacteria and high temperatures.

5. COLOR OF RED WINES. It is difficult to determine exactly the influence exerted by the $SO_2$ on the color on account of unavoidable variations in the grapes of the various vats. On the whole, there is no doubt, however, that it was favorable. The wines from the sulfited vats in nearly all instances were of better tint and more intense colors than those from the corresponding unsulfited vats.

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# COMMERCIAL FERTILIZERS

By JOHN S. BURD

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# COMMERCIAL FERTILIZERS

By JOHN S. BURD

The present bulletin comprises the results of the fertilizer inspection work of the California Fertilizer Control for the fiscal year ending June 30, 1912.

## REGISTERED MANUFACTURERS AND DEALERS

The following manufacturers and dealers in commercial fertilizers have obtained certificates of registration under the provisions of the California Fertilizer law, for the fiscal year beginning July 1, 1912. A list is also given of the brands of fertilizers and fertilizer materials offered by them for sale. According to the sworn returns of dealers registered for the fiscal year ending June 30, 1911, their entire sales in the state amounted to 49,764 tons. Nearly complete returns for the year ending June 30, 1912, indicate sales of over 50,000 tons.

No dealer or manufacturer, except those who have certificates of registration from the University of California, and their authorized agents, can legally sell fertilizers in this state. No person or company has any right to use any registration number except in connection with the firm name to which the registration certificate of such number has been issued; and no person or company to whom a registration number has been assigned has any right to give any other person or company permission to use said registration number, and any number so used is a fraud. No agent has any right to use his principal's registration number in connection with his own name.

**Agricultural Chemical Works, Los Angeles, Cal.**
Registration No. 8

Bat Guano.
Blood.
Bone Meal.
Brands A, B, C, D, E, F, G, H, J, K, L, M, and N.
Fish Guano.
Grape and Berry.
Gypsum.
Lawn and Rose.
Muriate of Potash.
Nitrate of Soda.
Nursery
Potato.
Prune and Peach.
Sulfate of Ammonia.
Sulfate of Potash.
Summer, A, B, and C.
Superphosphate.
Tankage.
Vegetable.
Walnut and Almond.

Special mixtures to order of consumers.

**American Agricultural Chemical Co., California Works, Los Angeles, Cal.**
Registration No. 1

Bradley's Acid Phosphate.
Bradley's California Vegetable.
Bradley's Fruit and Vine.
Bradley's Hay and Grain, No. 1.
Bradley's Hay and Grain, No. 2.
Bradley's Lawn.
Bradley's Lemon Tree.
Bradley's Nursery Stock.
Bradley's Orange and Lemon.
Bradley's Special Fruit and Vine.
Bradley's Special Nursery Stock.
Nitrate of Soda.
Raw Mineral Phosphate Rock.
Sulfate of Ammonia.
Sulfate of Potash.
Special brands to order.

**The Armour Fertilizer Works, Los Angeles, Cal.**
Registration No. 7

Bean Grower.
Bone Meal.
Bone, Blood and Potash.
Cotton Seed Meal.
Deciduous Tree Special.
Dried Blood.
Flower and Fern Food.
Fruit Special.
Fruit and Vine.
Guano.
Lawn and Garden Fertilizer.
Lawn Special.
Nitrate of Soda.
Olive Special.
Orange Tree Manure.
Sheep Manure.
Special 2–17–10.
Special 2–12–18.
Special 5–8–2.
Sulfate of Ammonia.
Sulfate of Potash.
Superphosphate.
Tankage.
Vegetable Grower.
Walnut Special.

Special mixtures to order of consumers.

**California Fertilizer Works, Inc., San Francisco, Cal.**
Registration No. 3

Fruit and Vine.
Fruit, Orange and Vine.
High Grade Bone and Blood Superphosphates.
Nursery Stock.
Odorless Lawn Dressing.
Orange Tree (B).
Special Bone and Blood Meal.
Special Orange Tree.
Special Orange (A).
Special Orange Tree, yellow leaves.
Peach.
Special Fertilizer with Iron Sulfate.
Special Fertilizer.
Special Fruit and Vine.
Special Orange and Lemon.
Special Nursery Stock.
Special Phosphate and Potash.
Truck and Berry.

**Chapman Fertilizer Co., Los Angeles, Cal.**
Registration No. 57

Chapman's Fall Application.
Chapman's Spring Application.

**Coronado Chemical Co., San Diego, Cal.**
Registration No. 65

Superphosphate "Cocheco" Brand.

**C. J. Duff, Glendale, Cal.**
Registration No. 58

Duff's Odorless Fertilizer, No. 1.
Duff's Odorless Fertilizer, No. 2.

**General Fertilizer Association, Los Angeles, Cal.**
Registration No. 42

G. F. A. Orange and Lemon No. 1.
G. F. A. Special No. 2.
G. F. A. No. 3.
G. F. A. No. 4.
G. F. A. No. 5 Ex Brand.
G. F. A. No. 6.
G. F. A. No. 8.
G. F. A. No. 9.
G. F. A. No. 10.
G. F. A. No. 11.
G. F. A. No. 15.
G. F. A. Special.
Lindsay Special.

**The Hauser Packing Co., Los Angeles, Cal.**
Registration No. 33

Concentrated Tankage.
Bone Meal.
Dried Blood.
Ground Sheep Manure.
Tankage.
Special mixtures to order.

**Hawaiian Fertilizer Co., Ltd., San Francisco, Cal.**
Registration No. 19

Blood.
Double Manure Salts.
Fish Guano.
Fruit and Vine.
Kainit.
Muriate of Potash.
Nitrate of Soda.
Nursery Stock.
Orange and Lemon.
Sulfate of Potash.
Superphosphate.
Thomas Phosphate
Tankage.
Special mixtures to order of consumers.

**Simon Levy, Los Angeles, Cal.**
Registration No. 37

Sheep Manure

**Thomas Lewis, Sacramento, Cal.**
Registration No. 40

Tom Lewis Bone Meal.
Tom Lewis Fertilizer.
Tom Lewis Star Brand Fertilizer.

**Los Angeles Fertilizer Co., Los Angeles, Cal.**
Registration No. 38

Three Queens Animal Bone and Potash.
Three Queens Emerson's Olive Special.
Three Queens Emerson's Summer Special.
Three Queen's Emerson's Vegetable Special.
Three Queen's Emerson's Walnut Special.
Three Queens Fruit Grower.
Three Queens Fruitmore.
Three Queens Garden and Lawn.
Three Queens Hanson's Odorless.
Three Queens L. A. Bone Meal.
Three Queens Nitrate of Soda.
Three Queens Orangeaid.
Three Queens Special Fruitgrower.
Three Queens Spring Special.
Three Queens Sulfate of Potash.
Three Queens Superphosphate.
Three Queens Tankage.
Three Queens T. and P.
Special mixtures to order of consumers.

**Morris & Co., Chicago, Ill.**

W. B. Burr, 307 Central Bldg., Los Angeles, Cal., Agent

Registration No. 26

Ground High Grade Blood.
Pacific Big One.
Pacific Big Two.
Pacific Big Three.
Pacific Big Four.
Pacific Big Five.
Pacific Big Six.
Pacific Big Seven.
Pacific Big Eight.
Pacific Big Nine.
Pacific Big Ten.
Pacific Big Eleven.

Special mixtures to order of consumers.

**The Mountain Copper Co., San Francisco, Cal.**

Registration No. 28

Mococo Superphosphate 0–17–0.
Mococo Superphosphate 0–20–0.
Mococo 0–3–3.
Mococo 0–12–8.
Mococo 0–14–9.
Mococo 1½–12–1½.
Mococo 2½–10-8.
Mococo 3–10–2.
Mococo 3–10–5.
Mococo 4–10–1½.
Mococo 4–10–4.
Mococo 5–10–4.
Nitrate of Soda.
Sulfate of Potash.

Special mixtures to order of consumers.

**Nitrate Agencies Co., Los Angeles, Cal.**

Registration No. 45

Bone Meal.
Nitrate of Soda.
Sulfate of Potash.
Superphosphate.

**North American Mercantile Co., San Francisco, Cal.**

Registration No. 61

Domoto Fertilizer.
Domoto Plant Food.
Rape Seed Meal.
Soy Bean Meal.

**Oakland Meat and Packing Co., Stock Yards, Cal.**

Registration No. 24

Special Fertilizer.

**Pacific Bone, Coal and Fertilizing Co., San Francisco, Cal.**

Registration No. 14

Arborette Brand.
Bone Meal.
Ceres Brand
Ceres Brand, No. 0.
Ceres Brand, No. 1.
Ceres Brand, No. 2.
Citrona Brand, No. 1.
Citrona Brand, No. 2.
Citrona Brand, No. 3.
"Flora" Brand.
Lupine Brand.
Lupine Brand, No. 2.
Merino Brand.
Muriate of Potash.
Nitrate of Soda.
Pomona Brand.
Pomona Brand, No. 1.
Pomona Brand, No. 2.
Pure Dissolved Bone Meal.
Sulfate of Potash.
Superphosphates.
Tankage.
Thomas Phosphate Powder.

Special mixtures to order of consumers.

**Pacific Coast Beef and Provision Co., Los Angeles, Cal.**

Registration No. 64

Bone Meal.
Tankage.

**Pacific Guano and Fertilizer Co., San Francisco, Cal.**

Registration No. 4

Bat Guano.
Raw Bone Meal.
Steamed Bone Meal.
Double Manure Salt.
Dried Blood.
(F) Fruit and Vine.
(H) Hops.
(B) Lawn Dressing.
Muriate of Potash.
Nitrate of Soda.
(N) Nursery Stock.
(O) Orange.
Special 8–6–2.
(PP) Special Phosphate and Potash.
(SS) Special Sugar Beet.
Sulfate of Ammonia.
Sulfate of Potash.
Supergyp.
Superphosphate.
Basic Superphosphate.
Tankage.
(GG) Grain Grower.
(PNK) Phosphorus, Nitrogen and Kalium.
(T) Truck.

Special mixtures to order of consumers.

**Pacific Wood and Coal Co., San Diego, Cal.**

Registration No. 53

(BG) Complete.
(BG) Lawn.
(BG) Soil Regulator.
(BG) Tree Tonic.
Nitrate of Soda.
Sulfate of Potash.
Superphosphate.

**Producers' Fertilizer Co., Los Angeles, Cal.**

Registration No. 56

Ground Sheep Manure.
Unground Sheep Manure.

**Redlands Fertilizer Association, Redlands, Cal.**

Registration No. 49

Bone Meal.
Fish Bone.
Gypsum.
Nitrate of Soda.
Nitrate of Lime.
Sulfate of Potash.
Superphosphate.
Sheep Manure.

Special mixtures to order of consumers.

**Redlands Fruit Association, Redlands, Cal.**

Registration No. 34

Fish Bone Meal.
Fish Scrap.
Nitrate of Soda.
Nitrate of Lime.
Royal Knight
Royal Knight Summer Special.
Sulfate of Potash.
Tankage.

**Standard Rendering Co., Kansas City, Mo.**

Registration No. 44

Standard One.
Standard Two.
Standard Three.
Standard Four.
Standard Concentrated.
Standard Bone.

**Standard Supply Co., Los Angeles, Cal.**

Registration No. 60

Fish Guano.
Standard No. 1.
Standard No. 2.
Standard No. 3.
Standard No. 4.
Standard No. 6.

**Swift & Co., Chicago, Ill.**

Registration No. 5

Swift's Diamond "C" Fertilizer.
Swift's Diamond "D" Fertilizer.
Swift's Diamond "E" Fertilizer.
Swift's Diamond "K" Fertilizer.
Swift's Diamond "L" Fertilizer.
Swift's Diamond "M" Fertilizer.
Swift's Ground Blood.
Swift's Acidulated Bone Meal.
Swift's Special Bone Meal.
Swift's High Grade Tankage.

Special mixtures to order of consumers.

**Union Fertilizer Co., Los Angeles, Cal.**

Registration No. 9

Blood.
Bone Meal.
Fruiting Fertilizer.
Bat Guano.
Bird Guano.
Nitrate of Soda.
Nursery or Spring Fertilizer.
Special Fruiting.
Sulfate of Ammonia.
Sulfate of Potash.
Superphosphate.
Tankage.
Walnut.

Special mixtures to order of consumers.

**Union Superphosphate Co., San Francisco, Cal.**

Registration No. 31

Superphosphate

**Western Meat Company, San Francisco, Cal.**

Registration No. 11

Gold Bear A.
Gold Bear B.
Gold Bear C.
Gold Bear D.
Gold Bear E Tankage.
Gold Bear F Raw Bone Meal.
Gold Bear G.
Gold Bear H Pure Blood Meal.
Gold Bear I.
Gold Bear K.
Gold Bear L.
Gold Bear O.
Gold Bear R.

**Woodbridge Fertilizer Co., Los Angeles, Cal.**

Registration No. 22

Bone Meal.
Citrus A.
Nitrate of Soda.
Muriate of Potash.
Orange.
Lawn.
Lemon.
Sulfate of Potash.
Tankage.

## SCOPE OF INSPECTION

During the year 636 samples of fertilizers and fertilizing materials have been received at the laboratory. Of this number 40 were sent by farmers under the two-dollar fee provision, 208 were taken by inspectors from purchasers' goods upon the request of the purchasers, and 296 were taken by inspectors from goods in the hands of agents and manufacturers. On 29* samples the analysis as reported was used as a basis of settlement by mutual agreement of buyer and seller. No guaranty was required or given with goods sold under such agreement. Sixty-three samples of a miscellaneous nature are omitted from the tables.

The following classification may be made of samples reported in this bulletin:

| | |
|---|---|
| Complete Fertilizers | 321 |
| Bone Meal | 57 |
| Tankage | 74 |
| Superphosphate | 35 |
| Dried Blood | 21 |
| Nitrate of Soda | 26 |
| Nitrate of Lime | 1 |
| Sulfate of Potash | 17 |
| Bat Guano | 10 |
| Bird Guano Phosphate | 1 |
| Superphosphate and Potash | 7 |
| Thomas Phosphate Powder and Potash | 1 |
| Thomas Phosphate Powder | 1 |
| Sulfate of Ammonia | 1 |
| | 573 |

## DEFICIENCIES

In the analyses of the above samples, the following number of deficiencies greater than that allowed by law occurred:

| | |
|---|---|
| Available Phosphoric Acid (total when available is not guaranteed) | 30 |
| Total Nitrogen | 56 |
| Potash | 34 |
| In valuation | 36 |

These deficiencies were found in 115 samples.

The fertilizer law allows a deficiency of 0.25 per cent in nitrogen, 0.50 per cent in potash, and 1 per cent in avaidable phosphoric acid.

## FERTILIZER VALUATIONS

The calculations of the commercial values of the the fertilizers here reported are made on the so-called unit basis. Such calculations consist simply in multiplying the number of per cent of each ingredient by the price per unit and adding the products. The sum thus obtained is the commercial value per ton at the prices used. If it is desired to use such a calculation for determining the amount which should be paid for goods, or the rebate to which the buyer is entitled owing to the goods delivered being below the guaranty, it can only be satisfactorily done if a definite price per unit has been agreed upon between buyer and seller. But for the mere purpose of showing the relative

* Besides these a considerable number of the remaining purchasers' analyses were doubtless used subsequently as a basis of settlement, but without being reported to this office.

values of goods to guaranties, it is not at all necessary that the prices adopted should be the exact market prices. Thus it is that the Fertilizer Control in attempting to show the relation between values found and values claimed, uses a schedule which is admittedly only an approximate average of market values. Owing to market fluctuations, differences in cost of delivery at different points, and other causes, the obtaining of true average market prices is an impossibility. But if the reader will bear in mind the true purpose of the valuations reported, these will have served their turn and he will not be led to assume that the Experiment Station is dictating the prices at which goods shall be sold.

SCHEDULE OF TRADE VALUES, 1912–1913

| | Cents per pound. | Value per unit. |
|---|---|---|
| Nitrogen from blood | 22.5 | $4.50 |
| Nitrogen from tankage and bone | 21.5 | 4.30 |
| Nitrogen from ammonia sulfate | 18.4 | 3.68 |
| Nitrogen from nitrate of soda | 15.4 | 3.08 |
| Phosphoric Acid from tankage | 3.6 | 0.72 |
| Phosphoric Acid from bone | 4.5 | 0.90 |
| Phosphoric Acid from bone superphosphate | 5.0 | 1.00 |
| Available Phosphoric Acid from rock superphosphate | 4.7 | 0.94 |
| Phosphoric Acid from Thomas Phosphate Powder | 4.2 | 0.84 |
| Potash from Sulfate of Potash | 5.7 | 1.14 |
| Potash from Muriate of Potash | 4.9 | 0.98 |

The base prices from which the above schedule is deduced are obtained as follows:

Blood and Tankage, Chicago market quotations and freight to Pacific Coast terminals.
Bone Meal, California manufacturers' estimates.
Sulfate of Ammonia, New York quotations and a differential freight rate based on Chicago production and delivery to California terminals.
Nitrate of Soda, California manufacturers' estimates and actual sales.
Potash Salts, New York quotations and differential freight rate (by sea) to California points.
Bone Superphosphate, local manufacturers' estimates.
Thomas Phosphate Powder, local manufacturers' estimates.
Rock Superphosphates, factory price, San Francisco Bay, and freight to Southern California points.

## CAUTION TO FERTILIZER CONSUMERS

It cannot be too frequently pointed out that the commercial value and the agricultural value of fertilizers is in no way related. The choice of the kind of plant food to be purchased should be based on a knowledge of the needs of the particular crop and soil to be treated. Only after this is decided should the cost of the fertilizer be considered, when the particular kind of fertilizer supplying the ingredient desired should be selected according to its agricultural availability and cost.

The elimination from the schedule of estimates of the commercial value of insoluble phosphoric acid and of fine and medium bone and tankage make it necessary that consumers pay particular attention in

the analytic reports to the figures for availability and fineness. Heretofore the use of such valuations has reflected the inferiority of goods of low availability and fineness in the calculated value per ton. This is not the case under the present schedule, hence the importance of buying and insisting on receiving goods of high availability and degree of fineness.

## REPORT OF ANALYSES

Available phosphoric acid is not determined in bone meal, tankage, and Thomas phosphate powder, unless requested. The fineness of these materials is determined, fine and medium bone being separated by a sieve of 50 meshes to the inch; tankage by a 25-mesh sieve; and Thomas phosphate powder by a 100-mesh sieve.

Nitrogen in ammonia salts will, in some cases, be found reported when notrogen in this form is not guaranteed. In some of such cases this form of nitrogen is produced by conversion of organic nitrogen during process of manufacture, and is not to be considered a deviation from guaranty of materials used. Guanos carry more or less nitrogen in nitrates and ammonia salts, and when any appreciable quantity of guano is used the manufacturer should take into account the fact that some nitrogen will show as nitrates and ammonia salts. The failure to take this into consideration may perhaps account for the appearance of these forms of nitrogen in some samples in which only organic nitrogen was guaranteed.

The percentage of chlorin is given when it exceeds 0.50 per cent. It is a matter of only technical interest whether chlorin present is from muriate of potash, kainit, or from common salt that may be in some of the materials used. If a manufacturer uses sulfate of potash and uses a tankage with it containing a large amount of chlorin, from a practical standpoint he has lowered the grade of his fertilizer just as much as if he had used muriate of potash instead of sulfate of potash. Chlorin from all other sources is as objectionable as from muriate of potash. However, if muriate of potash is found when sulfate is guaranteed, the fact will be published.

The following abbreviations are used in the tables: Bl = blood, Bn = bone, Fs = fish, G = guano, Super = superphosphates, T = tankage, H = hoof, Min. Phos. = mineral phosphate, CSM = cotton seed meal, T. P. P. = Thomas phosphate powder, Sm = Sheep manure.

Guarantees are entered in *italics*. Deficiencies greater than allowed by law are entered in bold type.

## ANALYSES AND VALUATIONS.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Agricultural Chemical Works, Los Angeles, Cal.** | | |
| 3624 | "A" | E. A. Moore, Redlands | $26.30 |
| 3632 | "A" | G. A. Herdeg, Riverside | 26.48 |
| 3988 | "A" | T. R. Woodbridge, Upland | 26.51 |
| | *Guaranteed* | | *26.18* |
| 3841 | "B" | J. M. Webster, Upland | 31.57 |
| | *Guaranteed* | | *29.60* |
| 3796 | Bat Guano | So. Cal. N. & F. Co., Santa Barbara | **24.44** |
| | *Guaranteed* | | *27.78* |
| 3839* | Bat Guano | J. M. Webster, Upland | *45.16 |
| | *Guaranteed* | | *50.54* |
| 3626 | Blood | E. A. Moore, Redlands | 62.63 |
| | *Guaranteed* | | *63.72* |
| 3838 | Blood | J. M. Webster, Upland | 64.99 |
| 3989 | Blood | T. R. Woodbridge, Upland | 65.37 |
| | *Guaranteed* | | *63.24* |
| 3625 | "C" | E. A. Moore, Redlands | 31.94 |
| 3630 | "C" | G. A. Herdeg, Riverside | 32.28 |
| 3698 | "C" | Mrs. J. A. Maddock, Duarte | 32.48 |
| 3987 | "C" | T. R. Woodbridge, Upland | 33.99 |
| 4013 | "C" | P. F. McManns, Lankershim | 33.48 |
| 4160 | "C" | Mrs. J. A. Maddock, Duarte | 35.58 |
| | *Guaranteed* | | *32.42* |
| 3694 | "F" | Gowen & Willard, Santa Ana | 25.23 |
| 3785 | "F" | H. C. Harding, San Fernando | 24.36 |
| | *Guaranteed* | | *24.52* |
| 3621 | "K" | E. A. Moore, Redlands | 25.97 |
| 3693 | "K" | Gowen & Willard, Santa Ana | 28.56 |
| 4208 | "K" | John E. Scott, Upland | 26.39 |
| | *Guaranteed* | | *27.04* |
| 3840 | "L" | J. M. Webster, Upland | 28.58 |
| | *Guaranteed* | | *27.64* |
| 3971* | Lawn | Morris & Snow S. Co., Los Angeles | 24.76 |
| | *Guaranteed* | | *23.85* |
| 4031 | N | Dr. R. Ludden, Colton | 34.86 |
| | *Guaranteed* | | *33.28* |
| 3696 | Nitrate of Soda | Gowen & Willard, Santa Ana | 42.84 |
| | *Guaranteed* | | *42.30* |

*3839—Discrepancy in valuation due to inadequacy of guaranty.

*3971—Potash guaranteed as muriate.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 3624 | 3.86 | 3.14 | 7.00 | ..... | 1.95 | ..... | 2.28 | ..... | 4.23 | 2.98 | 2.98 | ..... |
| 3632 | 5.27 | 2.58 | 7.85 | ..... | 1.10 | ..... | 2.57 | ..... | **3.67** | 3.34 | 3.34 | ..... |
| 3988 | 5.60 | 3.10 | 8.70 | ..... | 2.02 | ..... | 1.91 | ..... | 3.93 | 2.99 | 2.99 | ..... |
| ..... | *5.00* | *3.00* | *8.00* | *Super Bn, T* | *2.00* | ..... | *2.00* | *Bat G, Bl, Bn* | *4.00* | *3.00* | *3.00* | ..... |
| 3841 | 4.82 | 2.88 | 7.70 | ..... | 2.63 | ..... | 3.00 | ..... | 5.63 | 2.44 | 2.44 | ..... |
| ..... | *4.00* | *4.00* | *8.00* | *Super, Bn, T* | *2.00* | ..... | *3.00* | *Bat G, Bl, Bn* | *5.00* | *2.00* | *2.00* | ..... |
| 3796 | ..... | ..... | 4.20 | ..... | 0.85 | 0.35 | 3.40 | ..... | **4.60** | ..... | **1.12** | ..... |
| ..... | ..... | ..... | *3.00* | ..... | ..... | ..... | *5.00* | ..... | *5.00* | ..... | *2.00* | ..... |
| 3839 | ..... | ..... | 3.25 | ..... | 2.25 | 1.02 | 6.67 | ..... | 9.94 | ..... | 2.01 | ..... |
| ..... | ..... | ..... | *3.50* | ..... | ..... | ..... | *10.00* | ..... | *10.00* | ..... | *2.00* | ..... |
| 3626 | ..... | ..... | ..... | ..... | ..... | ..... | 13.27 | ..... | 13.27 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.50* | ..... | *13.50* | ..... | ..... | ..... |
| 3838 | ..... | ..... | ..... | ..... | ..... | ..... | 13.77 | ..... | 13.77 | ..... | ..... | ..... |
| 3989 | ..... | ..... | ..... | ..... | ..... | ..... | 13.85 | ..... | 13.85 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.40* | ..... | *13.40* | ..... | ..... | ..... |
| 3625 | 6.56 | 2.34 | 8.90 | ..... | 3.38 | ..... | 2.40 | ..... | 5.78 | 2.25 | 2.25 | ..... |
| 3630 | 4.86 | 3.64 | 8.50 | ..... | **3.16** | 0.10 | 2.57 | ..... | 5.83 | 2.45 | 2.45 | 0.80 |
| 3698 | 5.03 | 2.92 | 7.95 | ..... | 2.84 | ..... | 2.94 | ..... | 5.78 | 2.73 | 2.73 | 0.88 |
| 3987 | 5.53 | 3.92 | 9.45 | ..... | 2.99 | ..... | 2.91 | ..... | 5.90 | 2.50 | 2.50 | ..... |
| 4013 | 4.64 | 4.06 | 8.70 | ..... | 2.92 | ..... | 3.00 | ..... | 5.92 | 2.52 | 2.52 | ..... |
| 4160 | 5.18 | 3.62 | 8.80 | ..... | 2.53 | 0.15 | 3.56 | ..... | 6.24 | 2.53 | 2.53 | ..... |
| ..... | *4.00* | *4.00* | *8.00* | *Super, Bn, T* | *3.00* | ..... | *3.00* | *Bat G, Bl, Bn* | *6.00* | *2.00* | *2.00* | ..... |
| 3694 | 5.04 | 2.56 | 7.60 | ..... | 0.83 | ..... | 2.30 | ..... | 3.13 | 4.21 | 4.21 | ..... |
| 3785 | 5.49 | 3.26 | 8.75 | ..... | 1.22 | ..... | 1.68 | ..... | 2.90 | 3.96 | 3.96 | 0.60 |
| ..... | *6.00* | *2.00* | *8.00* | *Super, T* | *1.00* | ..... | *2.00* | *Bat G, Bl, Bn* | *3.00* | *4.00* | *4.00* | ..... |
| 3621 | 6.85 | 2.95 | 9.80 | ..... | 2.60 | 0.13 | 1.17 | ..... | 3.90 | 2.67 | 2.67 | ..... |
| 3693 | 5.59 | 4.16 | 9.75 | ..... | 1.00 | ..... | 2.93 | ..... | 3.93 | ..... | 2.31 | 1.45 |
| 4208 | 5.84 | 3.16 | 9.00 | ..... | 1.88 | ..... | 2.07 | ..... | 3.95 | 2.33 | 2.33 | ..... |
| ..... | *6.00* | *4.00* | *10.00* | *Super, Bn, Bn, T* | *2.00* | ..... | *2.00* | *Bat G, Bl, Bn* | *4.00* | *2.00* | *2.00* | ..... |
| 3840 | 6.88 | 3.72 | 10.60 | ..... | 0.90 | ..... | 2.10 | ..... | 3.00 | 5.14 | 5.14 | ..... |
| ..... | *5.00* | *5.00* | *10.00* | *Super, Bn, T* | *1.00* | ..... | *2.00* | *Bat G, Bl, Bn* | *3.00* | *5.00* | *5.00* | ..... |
| 3971 | 6.76 | 4.74 | 11.50 | ..... | ..... | ..... | 2.40 | ..... | 2.40 | ..... | 2.37 | ..... |
| ..... | *5.00* | *5.00* | *10.00* | *Super, T* | ..... | ..... | *2.50* | *Bl, Bn* | *2.50* | ..... | *2.50* | ..... |
| 4031 | 6.41 | 3.74 | 10.15 | ..... | 2.37 | ..... | 2.70 | ..... | 5.07 | 5.02 | 5.02 | ..... |
| ..... | *5.00* | *5.00* | *10.00* | *Super, Bn, T* | *3.00* | ..... | *2.00* | *Bat G, Bl, Bn* | *5.00* | *5.00* | *5.00* | ..... |
| 3696 | ..... | ..... | ..... | ..... | 15.19 | ..... | ..... | ..... | 15.19 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... |

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Agricultural Chemical Works—** *Continued.* | | |
| 4207 | R | John E. Scott, Upland | 30.19 |
| | *Guaranteed* | | *29.69* |
| 3629 | Special | G. A. Herdeg, Riverside | 35.13 |
| | *Guaranteed* | | *35.02* |
| 3741 | Special | C. D. Hamilton, Banning | 29.21 |
| | *Guaranteed* | | *26.47* |
| 3990 | Special | C. J. Walton, Upland | 33.64 |
| | *Guaranteed* | | *32.42* |
| 4036 | Special | H. L. Hostetler, Covina | 43.78 |
| | *Guaranteed* | | *44.37* |
| 4169 | Special | William Bowring, Charter Oak | 40.22 |
| | *Guaranteed* | | *39.18* |
| 3635 | Sulfate of Ammonia | G. A. Herteg, Riverside | 73.21 |
| | *Guaranteed* | | *73.39* |
| 3837 | Sulfate of Potash | J. M. Webster, Upland | 56.59 |
| | *Guaranteed* | | *54.76* |
| 3811 | Summer A | C. J. Walton, Upland | 27.79 |
| | *Guaranteed* | | *25.54* |
| 3622 | Summer B | E. A. Moore, Redlands | 25.87 |
| 3826 | Summer B | G. A. Andreas, Upland | 27.49 |
| | *Guaranteed* | | *26.24* |
| 3627 | Summer C | E. A. Moore, Redlands | 32.42 |
| | *Guaranteed* | | *31.88* |
| 3633 | Superphosphate | G. A. Herdeg, Riverside | 20.77 |
| | *Guaranteed* | | *20.41* |
| 3634 | Superphosphate | G. A. Herdeg, Riverside | 16.32 |
| | *Guaranteed* | | *16.45* |
| 3739 | Superphosphate | H. D. Derwin, Upland | |
| | *Sold on Station Analysis.* | | |
| 3842* | Tankage | J. M. Webster, Upland | 33.71 |
| | *Guaranteed* | | *34.66* |
| 3695 | Walnut | Gowen & Willard, Santa Ana | 24.62 |
| | *Guaranteed* | | *24.59* |

*3842—80% fine.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 4207 | 5.39 | 3.16 | 8.55 | ..... | 2.02 | ..... | 2.93 | ..... | 4.95 | 2.45 | 2.45 | 0.60 |
| ..... | *4.00* | *4.00* | *8.00* | *Super, Bn, T* | *2.00* | ..... | *3.00* | *Bat G, Bl, Bn* | *5.00* | *2.00* | *2.00* | ..... |
| 3629 | 6.36 | 3.14 | 9.50 | ..... | 2.45 | ..... | 2.80 | ..... | 5.25 | 5.22 | 5.22 | 0.60 |
| ..... | *6.00* | *4.00* | *10.00* | *Super, Bn, T* | *2.00* | ..... | *3.00* | *Bat G, Bl, Bn* | *5.00* | *5.00* | *5.00* | ..... |
| 3741 | 8.01 | 1.94 | 9.95 | ..... | 2.35 | ..... | 2.35 | ..... | 4.70 | 1.68 | 1.68 | ..... |
| ..... | *9.00* | *1.00* | *10.00* | *Super, Bn* | *2.00* | ..... | *2.00* | *Bat G, Bl, Bn* | *4.00* | *1.50* | *1.50* | ..... |
| 3990 | 5.35 | 3.70 | 9.05 | ..... | 2.97 | ..... | 2.95 | ..... | 5.92 | 2.43 | 2.43 | ..... |
| ..... | *4.00* | *4.00* | *8.00* | *Super, Bn, T* | *3.00* | ..... | *3.00* | *Bat G, Bl, Bn* | *6.00* | *2.00* | *2.00* | ..... |
| 4036 | 8.70 | 3.80 | 12.50 | ..... | 1.54 | ..... | 5.91 | ..... | **7.45** | ..... | ..... | ..... |
| ..... | *4.00* | *6.50* | *10.50* | *Super, Bn, T* | *1.50* | ..... | *6.50* | *Bat G, Bl, Bn* | *8.00* | ..... | ..... | ..... |
| 4169 | 10.42 | 0.38 | 10.80 | ..... | 1.53 | ..... | 5.73 | ..... | 7.26 | ..... | ..... | ..... |
| ..... | *10.50* | ..... | ..... | *Super, Bn, T* | *1.50* | ..... | *5.50* | *Bat G, Bl, Bn* | *7.00* | ..... | ..... | ..... |
| 3635 | ..... | ..... | ..... | ..... | ..... | 20.45 | ..... | ..... | 20.45 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | *20.50* | ..... | ..... | *20.50* | ..... | ..... | ..... |
| 3837 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 49.64 | 49.64 | 1.46 |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | *48.00* | *48.00* | ..... |
| 3811 | 8.62 | 5.48 | 14.10 | ..... | ..... | ..... | 1.73 | ..... | 1.73 | 5.10 | 5.10 | ..... |
| ..... | *7.00* | *6.00* | *1300* | *Super, Bn, T* | ..... | ..... | *1.50* | *Bat G, Bl, Bn* | *1.50* | *5.00* | *5.00* | ..... |
| 3622 | **3.61** | 3.29 | 6.90 | ..... | ..... | ..... | 2.17 | ..... | 2.17 | 7.96 | 7.96 | 0.62 |
| 3826 | 6.07 | 3.78 | 9.85 | ..... | ..... | ..... | 1.90 | ..... | 1.90 | 7.88 | 7.88 | 0.60 |
| ..... | *5.00* | *3.00* | *8.00* | *Super, Bn, T* | ..... | ..... | *2.00* | *Bat G, Bl, Bn* | *2.00* | *8.00* | *8.00* | ..... |
| 3627 | 4.16 | 3.04 | 7.20 | ..... | 2.08 | ..... | 2.25 | ..... | 4.33 | 7.98 | 7.98 | 1.00 |
| ..... | *5.00* | *3.00* | *8.00* | *Super, Bn, T* | *2.00* | ..... | *2.00* | *Bat G, Bl, Bn* | *4.00* | *8.00* | *8.00* | ..... |
| 3633 | 22.10 | 0.50 | 22.60 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *21.71* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3634 | 17.36 | 0.24 | 17.60 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *17.50* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3739 | 17.66 | 0.34 | 18.00 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3842 | ..... | ..... | **12.25** | ..... | ..... | ..... | 5.35 | ..... | 5.35 | ..... | ..... | ..... |
| ..... | ..... | ..... | *13.50* | *Bn* | ..... | ..... | *5.35* | *Bl, Bn* | *5.35* | ..... | ..... | ..... |
| 3695 | 5.36 | 2.44 | 7.80 | ..... | 0.66 | ..... | 2.10 | ..... | 2.76 | 4.72 | 4.72 | ..... |
| ..... | *6.00* | *2.00* | *8.00* | *Super, Bn, T* | *1.00* | ..... | *2.00* | *Bat G, Bl, Bn* | *3.00* | *4.00* | *4.00* | ..... |

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **American Agricultural Chemical Co., Los Angeles, Cal.** | | |
| 3905 | Acid Phosphate | L. V. W. Brown, Riverside | 17.29 |
| | *Guaranteed* | | *15.04* |
| 3828 | Bradley's California Vegetable | F. E. Dudderar, Covina | 26.90 |
| 3874 | Bradley's California Vegetable | Pacific Wood & Coal Co., San Diego | 26.51 |
| 3972 | Bradley's California Vegetable | Morris & Snow S. Co., Los Angeles | 26.20 |
| | *Guaranteed* | | *24.72* |
| 3873 | Bradley's Fruit and Vine | Pacific Wood and Coal Co., San Diego | 24.41 |
| | *Guaranteed* | | *23.28* |
| 3617 | Bradley's Lawn | E. M. Cope Commercial Co., Redlands | 26.74 |
| 3678 | Bradley's Lawn | L. M. Jacobs, Pasadena | 26.94 |
| 3882 | Bradley's Lawn | Pacific Wood & Coal Co., San Diego | 26.28 |
| | *Guaranteed* | | *25.58* |
| 3871 | Bradley's Lemon Tree | Pacific Wood & Coal Co., San Diego | 26.47 |
| 4016 | Bradley's Lemon Tree | Escondido Citrus Union, Escondido | 27.27 |
| | *Guaranteed* | | *25.58* |
| 3618 | Bradley's Nursery Stock | E. M. Cope Commercial Co., Redlands | 26.74 |
| 3720 | Bradley's Nursery Stock | S. H. Barrett, East Highlands | 27.10 |
| 3770 | Bradley's Nursery Stock | W. L. Hale, Fullerton | 27.12 |
| 3797 | Bradley's Nursery Stock | Johnston Fruit Co., Santa Barbara | 26.90 |
| 3823 | Bradley's Nursery Stock | Hemet Orange Growers' Assn., Hemet | 29.39 |
| 3906 | Bradley's Nursery Stock | L. V. W. Brown, Riverside | 27.20 |
| 3946 | Bradley's Nursery Stock | N. L. Chapin, Rialto | 25.86 |
| 4025 | Bradley's Nursery Stock | Mtn. View O. & L. Assn., Upland | 27.19 |
| 4080 | Bradley's Nursery Stock | W. H. Grant, Porterville | 25.77 |
| 4110 | Bradley's Nursery Stock | Lindsay Citrus Assn., Lindsay | 28.29 |
| 4127 | Bradley's Nursery Stock | Paul I. Midler, Fair Oaks | 25.80 |
| 4156 | Bradley's Nursery Stock | Eben Boalt, Palermo | 26.60 |
| | *Guaranteed* | | *25.57* |
| 3616 | Bradleys' Orange and Lemon | E. M. Cope Commercial Co., Redlands | 26.08 |
| 3732 | Bradley's Orange and Lemon | J. F. Munro, Upland | 27.26 |
| | *Guaranteed* | | *24.78* |
| 3872 | Bradley's Orange and Lemon | Pacific Wood & Coal Co., San Diego | 26.87 |
| | *Guaranteed* | | *25.41* |
| 3801 | Bradely's Special Fruit and Vine | N. W. Blanchard, Santa Paula | 31.82 |
| | *Guaranteed* | | *30.62* |
| 3771 | Nitrate of Soda | W. L. Hale, Fullerton | 44.84 |
| | *Guaranteed* | | *44.61* |

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 3905 | 18.40 | 0.80 | 19.20 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *16.00* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3828 | 8.55 | 1.10 | 9.65 | ..... | 2.08 | 0.65 | 1.00 | ..... | 3.73 | 3.96 | 3.96 | ..... |
| 3874 | 8.25 | 1.10 | 9.35 | ..... | 2.14 | 0.65 | 0.91 | ..... | 3.70 | 4.08 | 4.08 | ..... |
| 3972 | 8.43 | 1.02 | 9.45 | ..... | 2.04 | 0.61 | 0.95 | ..... | 3.60 | 3.94 | 3.94 | ..... |
| ..... | *8.00* | *1.00* | *9.00* | *Super, Bn* | *1.90* | *0.60* | *0.80* | *Bat G, Bl Bn, T* | *3.30* | *4.00* | *4.00* | ..... |
| 3873 | 7.61 | 0.64 | 8.25 | ..... | 2.05 | 0.48 | 0.72 | ..... | 3.25 | 4.72 | 4.72 | ..... |
| ..... | *7.00* | *1.00* | *8.00* | *Super, Bn* | *1.75* | *0.60* | *0.55* | *Bat G, Bl Bn, T* | *2.90* | *5.00* | *5.00* | ..... |
| 3617 | 9.65 | 0.85 | 10.50 | ..... | 2.77 | 0.78 | 0.86 | ..... | 4.41 | 1.51 | 1.51 | ..... |
| 3678 | 9.70 | 0.80 | 10.50 | ..... | 2.53 | 0.78 | 1.00 | ..... | 4.31 | 1.71 | 1.71 | ..... |
| 3882 | 8.98 | 0.82 | 9.80 | ..... | 2.26 | 0.70 | 1.19 | ..... | 4.15 | 1.92 | 1.92 | ..... |
| ..... | *9.00* | *1.00* | *10.00* | *Super, Bn* | *2.35* | *0.75* | *1.00* | *Bat G, Bl, Bn, T* | *4.10* | *1.50* | *1.50* | ..... |
| 3871 | 9.11 | 1.04 | 10.15 | ..... | 2.37 | 0.72 | 1.09 | ..... | 4.18 | 1.85 | 1.85 | ..... |
| 4016 | 9.58 | 0.92 | 10.50 | ..... | 2.73 | 0.85 | 0.90 | ..... | 4.48 | 1.70 | 1.70 | ..... |
| ..... | *9.00* | *1.00* | *10.00* | *Super, Bn* | *2.35* | *0.75* | *1.00* | *Bat G, Bl, Bn, T* | *4.10* | *1.50* | *1.50* | ..... |
| 3618 | 9.72 | 1.08 | 10.80 | ..... | 2.62 | 0.81 | 0.87 | ..... | 4.30 | 1.48 | 1.48 | ..... |
| 3720 | 9.64 | 0.96 | 10.60 | ..... | 2.65 | 0.80 | 0.94 | ..... | 4.39 | 1.65 | 1.65 | ..... |
| 3770 | 9.39 | 1.16 | 10.55 | ..... | 2.60 | 0.80 | 0.98 | ..... | 4.38 | 1.69 | 1.69 | ..... |
| 3797 | 9.50 | 0.90 | 10.40 | ..... | 2.80 | 0.75 | 0.85 | ..... | 4.40 | 1.80 | 1.80 | ..... |
| 3823 | 10.63 | 1.52 | 12.15 | ..... | 2.69 | 0.88 | 1.00 | ..... | 4.57 | 1.71 | 1.71 | ..... |
| 3906 | 8.90 | 1.60 | 10.50 | ..... | 2.33 | 0.73 | 1.20 | ..... | 4.26 | 1.80 | 1.80 | ..... |
| 3946 | 8.91 | 1.64 | 10.55 | ..... | 2.44 | 0.66 | 0.90 | ..... | 4.00 | 1.73 | 1.73 | ..... |
| 4025 | 9.69 | 1.66 | 11.35 | ..... | 2.41 | 0.72 | 0.98 | ..... | 4.11 | 1.75 | 1.75 | ..... |
| 4080 | 8.80 | 1.60 | 10.40 | ..... | 2.35 | 0.80 | 0.85 | ..... | 4.00 | 1.76 | 1.76 | ..... |
| 4110 | 10.02 | 0.78 | 10.80 | ..... | 2.89 | 0.78 | 1.00 | ..... | 4.67 | 1.76 | 1.76 | ..... |
| 4127 | 9.10 | 1.00 | 10.10 | ..... | 2.50 | 0.65 | 1.00 | ..... | 4.15 | 1.55 | 1.55 | ..... |
| 4156 | 8.80 | 0.90 | 9.70 | ..... | 2.48 | 0.72 | 1.10 | ..... | 4.30 | 2.04 | 2.04 | ..... |
| ..... | *9.00* | *1.00* | *10.00* | *Super, Bn* | *2.35* | *0.75* | *1.00* | *Bat G, Bl, Bn, T* | *4.10* | *1.50* | *1.50* | ..... |
| 3616 | 8.82 | 0.88 | 9.70 | ..... | 2.47 | 0.76 | 0.80 | ..... | 4.03 | 2.67 | 2.67 | ..... |
| 3732 | 8.75 | 0.70 | 9.45 | ..... | 2.37 | 0.67 | 1.02 | ..... | 4.06 | 3.58 | 3.58 | ..... |
| ..... | *8.00* | *1.00* | *9.00* | *Super, Bn* | *2.20* | *0.70* | *0.80* | *Bat G, Bl, Bn, T* | *3.70* | *3.00* | *3.00* | ..... |
| 3872 | 8.93 | 1.62 | 10.55 | ..... | 2.05 | 0.92 | 0.76 | ..... | 3.73 | 3.33 | 3.33 | ..... |
| ..... | *8.00* | *1.00* | *9.00* | *Super, Bn* | *2.00* | *0.40* | *1.30* | *Bat G, Bl, Bn, T* | *3.70* | *3.00* | *3.00* | ..... |
| 3801 | 7.53 | 0.82 | 8.35 | ..... | 2.31 | 0.65 | 0.90 | ..... | 3.86 | 9.24 | **9.24** | 0.65 |
| ..... | *7.00* | *1.00* | *8.00* | *Super, Bn* | *2.50* | *0.40* | *0.60* | *Bat G, Bl Bn* | *3.50* | *10.00* | *10.00* | ..... |
| 3771 | ..... | ..... | ..... | ..... | 15.90 | ..... | ..... | ..... | 15.90 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.82* | ..... | ..... | ..... | *15.82* | ..... | ..... | ..... |

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Armour Fertilizer Works, Los Angeles, Cal.** | | |
| 4161* | Bat Guano | W. S. Corwin, Highland | *41.46 |
| | *Guaranteed* | | *44.72* |
| 3681 | Blood | N. H. Garrison, Ontario | 63.25 |
| | *Guaranteed* | | *61.36* |
| 4181 | Blood | Azusa Foothills Citrus Assn., Azusa | ..... |
| | *Sold on Station Analysis.* | | |
| 3680 | Bone, Blood and Potash | N. H. Garrison, Ontario | 31.90 |
| 3730 | Bone, Blood and Potash | Kenneth Carter, Monrovia | 35.39 |
| 3813 | Bone, Blood and Potash | W. E. Bartlett, Hemet | 34.53 |
| 3911 | Bone, Blood and Potash | W. T. Henderson, Riverside | 32.88 |
| 3932 | Bone, Blood and Potash | R. E. Fairchild, Redlands | 33.38 |
| 4014 | Bone Blood and Potash | J. D. Boley, Highland | 33.88 |
| 4017 | Bone, Blood and Potash | Escondido Citrus Union, Escondido | 33.25 |
| 4057 | Bone, Blood and Potash | J. D. Seal, Porterville | 34.02 |
| | *Guaranteed* | | *33.61* |
| 4187 | Bone, Blood and Potash | A. E. Thomason, Lindsay | 38.98 |
| | *Guaranteed* | | *36.22* |
| 3636* | Bone Meal | W. T. Henderson, Riverside | 37.65 |
| 3805* | Bone Meal | Irwindale Citrus Assn., Irwindale | 37.24 |
| 3910* | Bone Meal | W. T. Henderson, Riverside | 37.05 |
| | *Guaranteed* | | *38.68* |
| 3684* | Bone Meal | N. H. Garrison, Ontario | 39.15 |
| | *Guaranteed* | | *35.40* |
| 3729* | Bone Meal | Kenneth Carter, Monrovia | 38.26 |
| | *Guaranteed* | | *37.26* |
| 3759* | Bone Meal | A. H. Schroder, Pomona | 35.68 |
| 3789* | Bone Meal | Albert Miller, Highland | 35.77 |
| 3859* | Bone Meal | Chas. H. Low, Riverside | 37.30 |
| 3860* | Bone Meal | Chas. H. Low, Riverside | 38.76 |
| 3904* | Bone Meal | Upland Coop. F. & S. Co., Upland | 38.03 |
| 3935* | Bone Meal | R. E. Fairchild, Redlands | 38.03 |
| | *Guaranteed* | | *37.68* |
| 3820* | Bone Meal | L .S. Taylor, San Dimas | 39.30 |
| 3983* | Bone Meal | Everett Hudson, Los Angeles | 40.24 |
| | *Guaranteed* | | *33.40* |
| 3719 | Flower and Fern Food | G. S. Van Wagenen, Cucamonga | 33.54 |
| 3980 | Flower and Fern Food | Everett Hudson, Los Angeles | 32.06 |
| | *Guaranteed* | | *33.61* |
| 3716 | Fruit Special | G. S. Van Wagenen, Cucamonga | 22.88 |
| 3757 | Fruit Special | John Blake, Pasadena | 23.18 |
| | *Guaranteed* | | *21.67* |

*4161—Discrepancy in valuation due to inadequacy in guaranty.
*3636—55% fine.
*3805—48% fine.
*3910—58% fine.
*3684—56% fine.
*3729—60% fine.
*3759—53% fine.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 4161 | ..... | ..... | 6.75 | ..... | 1.89 | 1.40 | 4.90 | ..... | 8.19 | ..... | 3.21 | ..... |
| ..... | ..... | ..... | *6.65* | ..... | ..... | ..... | *7.95* | ..... | *7.95* | ..... | *3.00* | ..... |
| 3681 | ..... | ..... | ..... | ..... | ..... | ..... | 13.40 | ..... | 13.40 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.00* | ..... | *13.00* | ..... | ..... | ..... |
| 4181 | ..... | ..... | ..... | ..... | ..... | ..... | 13.42 | ..... | 13.42 | ..... | ..... | ..... |
| 3680 | 8.13 | 1.52 | 9.65 | ..... | 1.54 | 0.30 | 1.92 | ..... | 3.76 | 7.10 | 7.10 | 0.75 |
| 3730 | 8.35 | 2.70 | 11.05 | ..... | 1.70 | 0.25 | 2.00 | ..... | 3.95 | 8.37 | 8.37 | 0.80 |
| 3813 | 8.99 | 1.86 | 10.85 | ..... | 1.43 | 0.25 | 2.17 | ..... | 3.85 | 7.78 | 7.78 | 0.75 |
| 3911 | 8.38 | 1.22 | 9.60 | ..... | 1.63 | 0.30 | 2.02 | ..... | 3.95 | 7.38 | 7.38 | 0.80 |
| 3932 | 7.73 | 1.72 | 9.45 | ..... | 1.55 | 0.27 | 2.20 | ..... | 4.02 | 7.51 | 7.51 | 1.00 |
| 4014 | 8.52 | 1.78 | 10.30 | ..... | 1.64 | ..... | 2.26 | ..... | 3.90 | 7.60 | 7.60 | 0.80 |
| 4017 | 8.49 | 1.86 | 10.35 | ..... | 1.60 | ..... | 2.18 | ..... | 3.78 | 7.41 | 7.41 | 0.70 |
| 4057 | 8.34 | 2.16 | 10.50 | ..... | 1.70 | ..... | 2.25 | ..... | 3.95 | 7.43 | 7.43 | 0.75 |
| ..... | *8.00* | *2.00* | *10.00* | *Super, Bn, G* | *1.50* | ..... | *2.50* | *Bl, Bn G, T* | *4.00* | *7.00* | *7.00* | ..... |
| 4187 | ..... | ..... | 10.10 | ..... | ..... | ..... | 4.20 | ..... | 4.20 | 8.54 | 8.54 | ..... |
| ..... | ..... | ..... | *10.00* | *Bn, G* | ..... | ..... | *4.00* | *Bl, Bn, T* | *4.00* | *7.00* | *7.00* | ..... |
| 3636 | ..... | ..... | 24.20 | ..... | ..... | ..... | 2.95 | ..... | 2.95 | ..... | ..... | ..... |
| 3805 | ..... | ..... | 24.20 | ..... | ..... | ..... | 2.86 | ..... | 2.86 | ..... | ..... | ..... |
| 3910 | ..... | ..... | **23.60** | ..... | ..... | ..... | 2.95 | ..... | 2.95 | ..... | ..... | ..... |
| ..... | ..... | ..... | *25.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 3684 | ..... | ..... | 28.80 | ..... | ..... | ..... | 2.27 | ..... | 2.27 | ..... | ..... | ..... |
| ..... | ..... | ..... | *24.00* | ..... | ..... | ..... | *2.50* | ..... | *2.50* | ..... | ..... | ..... |
| 3729 | ..... | ..... | 28.00 | ..... | ..... | ..... | 2.25 | ..... | 2.25 | ..... | ..... | ..... |
| ..... | ..... | ..... | *27.00* | ..... | ..... | ..... | *2.25* | ..... | *2.25* | ..... | ..... | ..... |
| 3759 | ..... | ..... | 23.60 | ..... | ..... | ..... | 2.65 | ..... | **2.65** | ..... | ..... | ..... |
| 3789 | ..... | ..... | 24.60 | ..... | ..... | ..... | 2.45 | ..... | **2.45** | ..... | ..... | ..... |
| 3859 | ..... | ..... | 23.90 | ..... | ..... | ..... | 2.94 | ..... | 2.94 | ..... | ..... | ..... |
| 3860 | ..... | ..... | 23.90 | ..... | ..... | ..... | 3.26 | ..... | 3.26 | ..... | ..... | ..... |
| 3904 | ..... | ..... | 24.90 | ..... | ..... | ..... | 2.88 | ..... | 2.88 | ..... | ..... | ..... |
| 3935 | ..... | ..... | 24.90 | ..... | ..... | ..... | 2.88 | ..... | 2.88 | ..... | ..... | ..... |
| ..... | ..... | ..... | *24.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 3820 | ..... | ..... | 29.00 | ..... | ..... | ..... | 2.26 | ..... | 2.26 | ..... | ..... | ..... |
| 3983 | ..... | ..... | 25.20 | ..... | ..... | ..... | 3.30 | ..... | 3.30 | ..... | ..... | ..... |
| ..... | ..... | ..... | *22.00* | ..... | ..... | ..... | *2.50* | ..... | *2.50* | ..... | ..... | ..... |
| 3719 | 8.44 | 1.96 | 10.40 | ..... | 1.97 | 0.35 | 2.73 | ..... | 5.05 | 3.42 | 3.42 | 0.62 |
| 3980 | 8.80 | 1.70 | 10.50 | ..... | 2.07 | ..... | 2.56 | ..... | **4.63** | 3.56 | 3.56 | ..... |
| ..... | *8.00* | *2.00* | *10.00* | *Super, Bn, G* | *1.50* | ..... | *3.50* | *Bl, Bn, G* | *5.00* | *3.00* | *3.00* | ..... |
| 3716 | **6.71** | 4.04 | 10.75 | ..... | 0.42 | 0.20 | 0.98 | ..... | 1.60 | 4.99 | 4.99 | ..... |
| 3757 | 9.35 | 2.00 | 11.35 | ..... | 0.32 | 0.12 | 1.10 | ..... | 1.54 | 4.81 | 4.81 | ..... |
| ..... | *8.00* | *2.00* | *10.00* | *Super, Bn, G* | *0.50* | ..... | *1.00* | *Bl, Bn G, T* | *1.50* | *5.00* | *5.00* | ..... |

*3789—54% fine.
*3859—63% fine.
*3860—57% fine.
*3904—53% fine.
*3935—53% fine.
*3820—55% fine.
*3983—66% fine.

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Armour Fertilizer Works—** *Continued.* | | |
| 3717 | Fruit and Vine | G. S. Van Wagenen, Cucamonga | 29.70 |
| 3986 | Fruit and Vine | Everett Hudson, Los Angeles | 27.11 |
| 4066 | Fruit and Vine | Lindsay Feed & Fuel Co., Lindsay | 29.95 |
| | *Guaranteed* | | *26.78* |
| 4097 | Fruit and Vine | P. J. Pierce, Sanger | 28.18 |
| | *Guaranteed* | | *27.65* |
| 3728 | Lawn and Garden | Kenneth Carter, Monrovia | 23.18 |
| 3758 | Lawn and Garden | John Blake, Pasadena | 23.84 |
| 3883 | Lawn and Garden | H. P. Greene, San Diego | **21.23** |
| 3969 | Lawn and Garden | B. S. Claubes, San Fernando | 27.92 |
| 3984 | Lawn and Garden | Everett Hudson, Los Angeles | 23.43 |
| 4019 | Lawn and Garden | Irwin & Co., Escondido | 24.28 |
| 4054 | Lawn and Garden | J. D. Seal, Porterville | 27.41 |
| | *Guaranteed* | | *25.19* |
| 3982 | Lawn Special | Everett Hudson, Los Angeles | 27.79 |
| | *Guaranteed* | | *26.06* |
| 3909 | Nitrate of Soda | W. T. Henderson, Riverside | 44.58 |
| 4068 | Nitrate of Soda | Lindsay Feed & Fuel Co., Lindsay | 43.45 |
| | *Guaranteed* | | *42.30* |
| 3638 | Orange Tree Manure | W. T. Henderson, Riverside | 25.88 |
| 3683 | Orange Tree Manure | N. H. Garrison, Ontario | 27.18 |
| 3887 | Orange Tree Manure | James Mills, Riverside | 25.53 |
| 3889 | Orange Tree Manure | W. B. Glidden, Glendora | 25.43 |
| 3965 | Orange Tree Manure | B. S. Claubes, San Fernando | 27.20 |
| 4056 | Orange Tree Manure | J. D. Seal, Porterville | 27.14 |
| | *Guaranteed* | | *25.63* |
| 3613 | Special | Mtn. View O. & L. Assn., Upland | 28.44 |
| 3773 | Special | Santiago O. G. Assn., Orange | 30.03 |
| 4201 | Special | C. B. Buxton, Orange | 30.42 |
| | *Guaranteed* | | *30.84* |
| 3742 | Special | B. A. Maxwell, Riverside | 27.73 |
| | *Guaranteed* | | *28.77* |
| 3752 | Special | Rialto Orange-Lemon Assn., Rialto | 32.33 |
| | *Guaranteed* | | *32.14* |
| 3756 | Special | John Blake, Pasadena | 21.52 |
| | *Guaranteed* | | *24.16* |
| 3780 | Special | A. O. Hockenberry, Covina | 37.92 |
| | *Guaranteed* | | *37.52* |
| 3781 | Special | W. B. Glidden, Glendora | 22.76 |
| | *Guaranteed* | | *22.54* |

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 3717 | 6.81 | 1.84 | 8.65 | ..... | 0.90 | 0.16 | 1.12 | ..... | 2.18 | 11.26 | 11.26 | 0.80 |
| 3986 | 7.52 | 1.68 | 9.20 | ..... | 0.94 | 0.20 | 0.86 | ..... | 2.00 | 9.32 | **9.32** | 0.70 |
| 4066 | 6.82 | 0.48 | 7.30 | ..... | 0.52 | 0.20 | 1.28 | ..... | 2.00 | 12.83 | 12.83 | 0.80 |
| ..... | *6.00* | *2.00* | *8.00* | *Super, Bn, G* | *1.00* | ..... | *1.00* | *Bl, Bn, G, T* | *2.00* | *10.00* | *10.00* | ..... |
| 4097 | 6.65 | 1.70 | 8.35 | ..... | 1.20 | ..... | 1.05 | ..... | 2.25 | 10.23 | 10.23 | ..... |
| ..... | *6.00* | *2.00* | *8.00* | *Super, Bn, G* | *0.50* | ..... | *1.50* | *Bl, Bn G, T* | *2.00* | *10.00* | *10.00* | ..... |
| 3728 | 4.24 | 1.06 | 5.30 | ..... | 1.75 | 0.10 | 1.38 | ..... | **3.23** | 5.53 | 5.53 | ..... |
| 3758 | 5.62 | 0.78 | 6.40 | ..... | 1.56 | 0.20 | 1.70 | ..... | **3.46** | 4.02 | 4.02 | 0.75 |
| 3883 | 4.81 | 0.64 | 5.45 | ..... | 0.73 | 0.16 | 1.86 | ..... | **2.75** | 4.11 | 4.11 | ..... |
| 3969 | 5.08 | 1.02 | 6.10 | ..... | 1.64 | 0.20 | 2.43 | ..... | 4.27 | 4.74 | 4.74 | 0.90 |
| 3984 | 4.57 | 0.78 | 5.35 | ..... | 1.19 | 0.26 | 2.10 | ..... | **3.55** | 3.70 | 3.70 | 0.70 |
| 4019 | 6.88 | 1.42 | 8.30 | ..... | 1.24 | 0.30 | 2.03 | ..... | **3.57** | 1.89 | **1.89** | ..... |
| 4054 | 5.12 | 1.08 | 6.20 | ..... | 1.63 | ..... | 2.37 | ..... | 4.00 | 5.09 | 5.09 | 0.75 |
| ..... | *4.00* | *1.00* | *5.00* | *Super, Bn, G* | *1.50* | ..... | *2.50* | *Bl, Bn, G, T* | *4.00* | *4.00* | *4.00* | ..... |
| 3982 | ..... | ..... | 5.60 | ..... | 1.23 | 0.25 | 3.34 | ..... | 4.82 | 2.28 | 2.28 | 0.94 |
| ..... | ..... | ..... | *5.00* | *Bn, G* | *1.00* | ..... | *3.50* | *Bl, Bn, G, T* | *4.50* | *2.00* | *2.00* | ..... |
| 3909 | ..... | ..... | ..... | ..... | 15.81 | ..... | ..... | ..... | 15.81 | ..... | ..... | ..... |
| 4068 | ..... | ..... | ..... | ..... | 15.41 | ..... | ..... | ..... | 15.41 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... |
| 3638 | 7.68 | 2.72 | 10.40 | ..... | 1.59 | 0.20 | 1.20 | ..... | 2.99 | 4.22 | 4.22 | ..... |
| 3683 | 7.86 | 2.64 | 10.50 | ..... | 1.38 | 0.25 | 1.45 | ..... | 3.08 | 4.64 | 4.64 | ..... |
| 3887 | 8.11 | 1.44 | 9.55 | ..... | 1.52 | 0.15 | 1.41 | ..... | 3.08 | 4.17 | 4.17 | ..... |
| 3889 | 8.35 | 1.60 | 9.95 | ..... | 1.15 | 0.20 | 1.50 | ..... | 2.85 | 4.11 | 4.11 | ..... |
| 3965 | 8.01 | 2.44 | 10.45 | ..... | 1.36 | 0.17 | 1.53 | ..... | 3.06 | 4.68 | 4.68 | ..... |
| 4056 | 8.10 | 1.90 | 10.00 | ..... | 1.56 | ..... | 1.67 | ..... | 3.23 | 4.50 | 4.50 | ..... |
| ..... | *8.00* | *2.00* | *10.00* | *Super, Bn, G* | *1.50* | ..... | *1.50* | *Bl, Bn, G, T* | *3.00* | *4.00* | *4.00* | ..... |
| 3613 | 6.88 | 3.12 | 10.00 | ..... | 1.75 | 0.22 | 1.80 | ..... | 3.77 | 3.96 | **3.96** | ..... |
| 3773 | 7.20 | 2.60 | 9.80 | ..... | 1.74 | 0.23 | 1.58 | ..... | **3.55** | 6.42 | 6.42 | 0.65 |
| 4201 | 6.19 | 3.16 | 9.35 | ..... | 1.58 | 0.82 | 1.65 | ..... | 4.05 | 5.40 | 5.40 | 0.60 |
| ..... | *5.00* | *5.00* | *10.00* | *Super, Bn, G* | *1.50* | *0.50* | *2.00* | *Bl, Bn, G, T* | *4.00* | *5.00* | *5.00* | ..... |
| 3742 | 9.64 | 2.06 | 11.70 | ..... | 1.23 | 0.20 | 1.11 | ..... | **2.54** | 5.96 | 5.96 | ..... |
| ..... | *10.00* | *2.00* | *12.00* | *Super, Bn, G* | *1.50* | ..... | *1.50* | *Bl, Bn, G, T* | *3.00* | *5.00* | *5.00* | ..... |
| 3752 | 10.31 | 0.64 | 10.95 | ..... | 2.22 | 0.25 | 1.35 | ..... | 3.82 | 8.20 | 8.20 | 0.70 |
| ..... | *10.00* | ..... | ..... | *Super, Bn, G* | *2.00* | ..... | *2.00* | *Bl, Bn, G, T* | *4.00* | *7.00* | *7.00* | ..... |
| 3756 | ..... | ..... | 5.50 | ..... | 0.90 | 0.35 | 2.15 | ..... | **3.40** | 2.13 | 2.13 | ..... |
| ..... | ..... | ..... | *5.00* | *Bn, G* | *0.50* | *0.50* | *3.00* | *Bn, G* | *4.00* | *2.00* | *2.00* | ..... |
| 3780 | ..... | ..... | 16.30 | ..... | ..... | ..... | 2.40 | ..... | 2.40 | 9.37 | **9.37** | 0.75 |
| ..... | ..... | ..... | *17.00* | *Bn* | ..... | ..... | *2.00* | *Bn* | *2.00* | *10.00* | *10.00* | ..... |
| 3781 | 8.55 | 1.95 | 10.50 | ..... | ..... | ..... | 1.56 | ..... | 1.56 | 4.52 | 4.52 | ..... |
| ..... | *8.00* | *2.00* | *10.00* | *Super, Bn, G* | ..... | ..... | *1.50* | *Bl, Bn, G, T* | *1.50* | *5.00* | *5.00* | ..... |

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Armour Fertilizer Works—** *Continued.* | | |
| 3827 | Special | H. L. Hostetler, Covina | 41.48 |
| | *Guaranteed* | | *36.10* |
| 3974 | Special | J. S. Phelps, Redlands | 31.36 |
| | *Guaranteed* | | *31.98* |
| 4030 | Special | West Highland Citrus Assn., Highland | 24.10 |
| 4139 | Special | West Highland Citrus Assn., Highland | 23.34 |
| 4140 | Special | West Highland Citrus Assn., Highland | 27.14 |
| 4141 | Special | West Highland Citrus Assn., Highland | 26.81 |
| | *Guaranteed* | | *25.58* |
| 4058 | Special | J. D. Seal, Porterville | 29.61 |
| | *Guaranteed* | | *29.37* |
| 4067 | Special | Lindsay Feed & Fuel Co., Lindsay | 29.21 |
| | *Guaranteed* | | *29.05* |
| 4069 | Special | W. S. Cairns, Lindsay | 34.40 |
| | *Guaranteed* | | *32.61* |
| 4076 | Special | Robert Baird, Portervile | 34.81 |
| | *Guaranteed* | | *33.85* |
| 4096 | Special | P. J. Pierce, Sanger | 2942 |
| | *Guaranteed* | | *28.50* |
| 4143 | Special | N. R. Benson, Rialto | 27.02 |
| | *Guaranteed* | | *29.04* |
| 4186 | Special | N. R. Benson, Rialto | 31.03 |
| | *Guaranteed* | | *32.42* |
| 4211 | Special | Arlington Hts. Fruit Co., Riverside | 34.31 |
| 4212 | Special | Arlington Hts. Fruit Co., Riverside | 35.61 |
| 4219 | Special | Arlington Hts. Fruit Co., Riverside | 34.05 |
| 4220 | Special | Arlington Hts. Fruit Co., Riverside | 35.01 |
| 4226 | Special | Arlington Hts. Fruit Co., Riverside | 34.58 |
| 4227 | Special | Arlington Hts. Fruit Co., Riverside | 34.62 |
| 4228 | Special | Arlington Hts. Fruit Co., Riverside | 34.39 |
| 4229 | Special | Arlington Hts. Fruit Co., Riverside | 36.03 |
| 4230 | Special | Arlington Hts. Fruit Co., Riverside | 33.26 |
| 4233 | Special | Arlington Hts. Fruit Co., Riverside | 32.82 |
| 4234 | Special | Arlington Hts. Fruit Co., Riverside | 34.40 |
| 4235 | Special | Arlington Hts. Fruit Co., Riverside | 35.30 |
| 4240 | Special | Arlington Hts. Fruit Co., Riverside | 35.92 |
| 4241 | Special | Arlington Hts. Fruit Co., Riverside | 32.94 |
| 4242 | Special | Arlington Hts. Fruit Co., Riverside | 35.13 |
| | *Guaranteed* | | *34.64* |
| 3679 | Special 5-8-2 | N. H. Garrison, Ontario | 26.09 |

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 3827 | 12.28 | 6.32 | 18.60 | ..... | ..... | ..... | 0.70 | ..... | 0.70 | 17.27 | 17.27 | 0.75 |
| ..... | ..... | ..... | *19.00* | *Super, Bn* | ..... | ..... | *0.75* | *Bn* | *0.75* | *12.00* | *12.00* | ..... |
| 3974 | 7.57 | 2.48 | 10.05 | ..... | 1.63 | 0.70 | 2.56 | ..... | 4.89 | 2.23 | 2.23 | ..... |
| ..... | *5.00* | *5.00* | *10.00* | *Super, Bn, G* | *1.50* | *0.50* | *3.00* | *Bl, Bn, C.S.M., G* | *5.00* | *2.00* | *2.00* | ..... |
| 4030 | 9.16 | 0.94 | 10.10 | ..... | 1.65 | 0.80 | 0.95 | ..... | **3.40** | 1.90 | 1.90 | ..... |
| 4139 | 8.02 | 1.08 | 9.10 | ..... | 2.30 | 0.52 | 0.80 | ..... | **3.62** | 1.97 | 1.97 | ..... |
| 4140 | 9.66 | 1.24 | 10.90 | ..... | 2.29 | 0.53 | 1.30 | ..... | 4.12 | 1.71 | 1.71 | ..... |
| 4141 | 9.80 | 1.00 | 10.80 | ..... | 2.53 | 0.67 | 1.05 | ..... | 4.25 | 1.48 | 1.48 | ..... |
| ..... | *9.00* | *1.00* | *10.00* | *Super, Bn, G* | *2.35* | *0.75* | *1.00* | *Bl, Bn, G, T* | *4.10* | *1.50* | *1.50* | ..... |
| 4058 | 9.10 | 2.60 | 11.70 | ..... | 0.65 | 0.15 | 1.45 | ..... | 2.25 | 7.83 | 7.83 | 0.62 |
| ..... | *8.00* | *4.00* | *12.00* | *Super, Bn, G* | *0.50* | ..... | *1.50* | *Bl, Bn, CSM, G, T* | *2.00* | *8.00* | *8.00* | ..... |
| 4067 | 7.50 | 2.00 | 9.50 | ..... | 1.65 | ..... | 1.43 | ..... | 3.08 | 7.49 | 7.49 | 0.60 |
| ..... | *8.00* | *2.00* | *10.00* | *Super, Bn, G* | *1.50* | ..... | *1.50* | *Bl, Bn, CSM, G, T* | *3.00* | *7.00* | *7.00* | ..... |
| 4069 | 7.01 | 2.64 | 9.65 | ..... | 1.81 | ..... | 2.40 | ..... | 4.21 | 7.64 | 7.64 | 0.70 |
| ..... | *6.00* | *3.00* | *9.00* | *Super, Bn, G* | *1.50* | ..... | *2.50* | *Bl, Bn, CSM, G, T* | *4.00* | *7.00* | *7.00* | ..... |
| 4076 | 7.66 | 1.64 | 9.30 | ..... | 2.67 | ..... | 2.10 | ..... | 4.77 | 7.39 | 7.39 | 0.75 |
| ..... | *7.60* | *1.90* | *9.50* | *Super, Bn, G* | *2.15* | ..... | *2.35* | *Bl, Bn, G, T* | *4.50* | *6.65* | *6.65* | ..... |
| 4096 | 8.55 | 3.10 | 11.65 | ..... | 1.12 | ..... | 1.10 | ..... | 2.22 | 8.42 | 8.42 | ..... |
| ..... | *8.00* | *4.00* | *12.00* | *Super, Bn, G* | *1.00* | ..... | *1.00* | *Bl, Bn, G, T* | *2.00* | *8.00* | *8.00* | ..... |
| 4143 | ..... | ..... | 12.30 | ..... | 1.69 | 0.15 | 1.50 | ..... | **3.34** | 2.27 | 2.27 | ..... |
| ..... | ..... | ..... | *12.00* | *Super, Bn, G* | *2.00* | ..... | *2.00* | *Bl, Bn, G, T* | *4.00* | *2.00* | *2.00* | ..... |
| 4186 | ..... | ..... | 7.50 | ..... | 3.78 | ..... | 2.50 | ..... | 6.28 | 2.19 | 2.19 | ..... |
| ..... | ..... | ..... | *8.00* | *Super, Bn, G* | *3.00* | ..... | *3.00* | *Bl, Bn, CSM, G, T* | *6.00* | *2.00* | *2.00* | ..... |
| 4211 | ..... | ..... | 5.20 | ..... | ..... | ..... | 5.76 | ..... | 5.76 | 2.50 | 2.50 | 0.80 |
| 4212 | ..... | ..... | 5.65 | ..... | ..... | ..... | 5.91 | ..... | 5.91 | 2.64 | 2.64 | 0.80 |
| 4219 | ..... | ..... | 5.35 | ..... | ..... | ..... | 5.77 | ..... | 5.77 | 2.10 | 2.10 | 0.80 |
| 4220 | ..... | ..... | 5.20 | ..... | ..... | ..... | 5.90 | ..... | 5.90 | 2.56 | 2.56 | 0.80 |
| 4226 | ..... | ..... | 6.20 | ..... | ..... | ..... | 5.76 | ..... | 5.76 | 1.86 | 1.86 | 0.80 |
| 4227 | ..... | ..... | 5.25 | ..... | ..... | ..... | 5.77 | ..... | 5.77 | 2.69 | 2.69 | 0.80 |
| 4228 | ..... | ..... | 5.50 | ..... | ..... | ..... | 5.80 | ..... | 5.80 | 2.14 | 2.14 | 0.75 |
| 4229 | ..... | ..... | 5.35 | ..... | ..... | ..... | 6.00 | ..... | 6.00 | 2.91 | 2.91 | 0.80 |
| 4230 | ..... | ..... | 6.00 | ..... | ..... | ..... | 5.45 | ..... | **5.45** | 2.11 | 2.11 | 0.70 |
| 4233 | ..... | ..... | 5.45 | ..... | ..... | ..... | 5.46 | ..... | **5.46** | 2.17 | 2.17 | 0.80 |
| 4234 | ..... | ..... | 5.30 | ..... | ..... | ..... | 5.87 | ..... | 5.87 | 2.05 | 2.05 | 0.90 |
| 4235 | ..... | ..... | 5.15 | ..... | ..... | ..... | 5.98 | ..... | 5.98 | 2.54 | 2.54 | 0.90 |
| 4240 | ..... | ..... | 5.65 | ..... | ..... | ..... | 6.00 | ..... | 6.00 | 2.55 | 2.55 | 0.95 |
| 4241 | ..... | ..... | 5.35 | ..... | ..... | ..... | 5.45 | ..... | **5.45** | 2.41 | 2.41 | 0.90 |
| 4242 | ..... | ..... | 5.20 | ..... | ..... | ..... | 5.97 | ..... | 5.97 | 2.38 | 2.38 | 0.80 |
| ..... | ..... | ..... | *5.00* | *Bn, T* | ..... | ..... | *6.00* | *Bl, Bn, T* | *6.00* | *2.00* | *2.00* | ..... |
| 3679 | 7.76 | 1.64 | 9.40 | ..... | 1.29 | 0.20 | 2.08 | ..... | **3.57** | 2.50 | 2.50 | 0.60 |

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Armour Fertilizer Works—** *Continued.* | | |
| 3718 | Special *5–8–2* | G. S. Van Wagenen, Cucamonga | 30.28 |
| 3812 | Special *5–8–2* | W. E. Bartlett, Hemet | 28.13 |
| 3912 | Special *5–8–2* | W. T. Henderson, Riverside | 26.95 |
| 3933 | Special *5–8–2* | R. E. Fairchild, Redlands | 28.14 |
| 3934 | Special *5–8–2* | R. E. Fairchild, Redlands | 28.43 |
| 3964 | Special *5–8–2* | B. S. Claubes, San Fernando | 25.44 |
| 4018 | Special *5–8–2* | Escondido Citrus Union, Escondido | 28.81 |
| 4055 | Special *5–8–2* | Frank Neumann, Success | 29.13 |
| | *Guaranteed* | | *27.91* |
| 3682 | Sulfate of Potash | N. H. Garrison, Ontario | 55.63 |
| 3877 | Sulfate of Potash | H. P. Greene, San Diego | 57.52 |
| 3936 | Sulfate of Potash | R. E. Fairchild, Redlands | **52.89** |
| | *Guaranteed* | | *54.72* |
| 3806 | Superphosphate | Irwindale Citrus Assn., Irwindale | 16.82 |
| | *Guaranteed* | | *15.98* |
| 4170* | Superphosphate | Chas. H. Low, Riverside | ..... |
| | *Sold on Station Analysis.* | | |
| 3637* | Tankage | W. T. Henderson, Riverside | 33.78 |
| 3731* | Tankage | Kenneth Carter, Monrovia | 30.98 |
| 3970* | Tankage | B. S. Claubes, San Fernando | 33.93 |
| | *Guaranteed* | | *32.68* |
| 3639* | Tankage | W. T. Henderson, Riverside | 40.41 |
| | *Guaranteed* | | *39.90* |
| 3685* | Tankage | N. H. Garrison, Ontario | 40.20 |
| | *Guaranteed* | | *40.28* |
| 3891* | Tankage | William Hagen, Duarte | 35.49 |
| 3962* | Tankage | A. B. Downe, Duarte | 35.31 |
| | *Guaranteed* | | *34.20* |
| 3993* | Tankage | P. J. Neilly, Claremont | 48.05 |
| 4038* | Tankage | A. H. Schroder, Pomona | 48.79 |
| 4047* | Tankage | W. C. Nickerson, Redlands | **46.88** |
| 4168* | Tankage | C. C. Cady, Covina | 51.01 |
| | *Guaranteed* | | *49.23* |
| 4202* | Tankage | B. L. King, Covina | 41.35 |
| | *Guaranteed* | | *42.01* |
| 3985 | Vegetable Grower | Everett Hudson, Los Angeles | **18.91** |
| | *Guaranteed* | | *25.19* |

*4170—Originally mislabeled "Orange Tree Manure."
*3637—77% fine.
*3731—66% fine.
*3970—70% fine.
*3639—94% fine.
*3685—87% fine.
*3891—69% fine.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 3718 | 7.67 | 2.58 | 10.25 | ..... | 2.27 | 0.25 | 2.00 | ..... | 4.52 | 3.18 | 3.18 | 0.75 |
| 3812 | 9.02 | 1.68 | 10.70 | ..... | 1.71 | 0.25 | 2.00 | ..... | 3.96 | 2.28 | 2.28 | 0.60 |
| 3912 | 7.91 | 1.24 | 9.15 | ..... | 1.71 | 0.40 | 1.90 | ..... | 4.01 | 2.54 | 2.54 | ..... |
| 3933 | 7.86 | 1.74 | 9.60 | ..... | 1.89 | ..... | 2.39 | ..... | 4.28 | 2.04 | 2.04 | ..... |
| 3934 | 8.65 | 1.60 | 10.25 | ..... | 1.66 | 0.25 | 2.18 | ..... | 4.09 | 2.35 | 2.35 | ..... |
| 3964 | 7.77 | 1.48 | 9.25 | ..... | 1.60 | 0.25 | 1.80 | ..... | **3.65** | 2.26 | 2.26 | ..... |
| 4018 | 9.31 | 1.64 | 10.95 | ..... | 1.55 | 0.15 | 2.18 | ..... | 3.88 | 2.64 | 2.64 | 0.60 |
| 4055 | 7.90 | 2.20 | 10.10 | ..... | 1.88 | ..... | 2.40 | ..... | 4.28 | 2.45 | 2.45 | ..... |
| ..... | *8.00* | *2.00* | *10.00* | *Super, Bn, G* | *1.50* | ..... | *2.50* | *Bl, Bn, G, T* | *4.00* | *2.00* | *2.00* | ..... |
| 3682 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 48.80 | 48.80 | 2.30 |
| 3877 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 50.46 | 50.46 | 1.20 |
| 3936 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 46.40 | **46.40** | 3.44 |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | *48.00* | *48.00* | ..... |
| 3806 | 17.91 | 0.34 | 18.25 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *17.00* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4170 | 18.64 | 0.46 | 19.10 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3637 | ..... | ..... | 11.80 | ..... | ..... | ..... | 5.44 | ..... | 5.44 | ..... | ..... | ..... |
| 3731 | ..... | ..... | **9.45** | ..... | ..... | ..... | 5.22 | ..... | 5.22 | ..... | ..... | ..... |
| 3970 | ..... | ..... | 13.75 | ..... | ..... | ..... | 5.15 | ..... | 5.15 | ..... | ..... | ..... |
| ..... | ..... | ..... | *11.50* | *Bn.* | | ..... | *5.25* | *Bl, Bn* | *5.25* | ..... | ..... | ..... |
| 3639 | ..... | ..... | 8.05 | ..... | ..... | ..... | 7.52 | ..... | 7.52 | ..... | ..... | ..... |
| ..... | ..... | ..... | *6.00* | *Bn* | ..... | ..... | *7.75* | *Bl, Bn* | *7.75* | ..... | ..... | ..... |
| 3685 | ..... | ..... | 7.60 | ..... | ..... | ..... | 7.55 | ..... | 7.55 | ..... | ..... | ..... |
| ..... | ..... | ..... | *6.50* | *Bn* | ..... | ..... | *7.75* | *Bl, Bn* | *7.75* | ..... | ..... | ..... |
| 3891 | ..... | ..... | 14.00 | ..... | ..... | ..... | 5.45 | ..... | 5.45 | ..... | ..... | ..... |
| 3962 | ..... | ..... | 13.30 | ..... | ..... | ..... | 5.53 | ..... | 5.53 | ..... | ..... | ..... |
| ..... | ..... | ..... | *12.00* | *Bn* | ..... | ..... | *5.50* | *Bl, Bn* | *5.50* | ..... | ..... | ..... |
| 3993 | ..... | ..... | 6.90 | ..... | ..... | ..... | 9.39 | ..... | **9.39** | ..... | ..... | ..... |
| 4038 | ..... | ..... | 5.95 | ..... | ..... | ..... | 9.71 | ..... | 9.71 | ..... | ..... | ..... |
| 4047 | ..... | ..... | 5.90 | ..... | ..... | ..... | 9.30 | ..... | **9.30** | ..... | ..... | ..... |
| 4168 | ..... | ..... | 6.05 | ..... | ..... | ..... | 10.18 | ..... | 10.18 | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.50* | *Bn* | ..... | ..... | *9.88* | *Bl, Bn* | *9.88* | ..... | ..... | ..... |
| 4202 | ..... | ..... | **14.80** | ..... | ..... | ..... | 6.60 | ..... | 6.60 | ..... | ..... | ..... |
| ..... | ..... | ..... | *16.54* | *Bn* | ..... | ..... | *6.46* | *Bl, Bn* | *6.46* | ..... | ..... | ..... |
| 3985 | 4.90 | 0.60 | 5.50 | ..... | 0.95 | 0.20 | 1.55 | ..... | **2.70** | 2.58 | **2.58** | ..... |
| ..... | *4.00* | *1.00* | *5.00* | *Super, Bn, G* | *1.50* | ..... | *2.50* | *Bl, Bn, G, T* | *4.00* | *4.00* | *4.00* | ..... |

*3962—65% fine.
*3993—66% fine.
*4038—66% fine.
*4047—61% fine.
*4168—76% fine.
*4202—87% fine.

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **California Fertilizer Works, San Francisco, Cal.** | | |
| 3705 | Blood | Hanson & Seares, Upland | 61.60 |
| | *Guaranteed* | | *54.33* |
| 3702* | Bone Meal | Hanson & Seares, Upland | 36.40 |
| | *Guaranteed* | | *31.40* |
| 4103 | Fruit, Orange and Vine | Sunnyside Vineyard Co., Fresno | 28.45 |
| | *Guaranteed* | | *27.58* |
| 3899 | Fruit and Vine | G. W. Hume Co., Los Gatos | 27.55 |
| | *Guaranteed* | | *27.68* |
| 3646* | High Grade Bone and Bl. Meal | R. T. Godfrey, Riverside | 43.67 |
| 3704* | High Grade Bone and Bl. Meal | Hanson & Seares, Upland | 43.08 |
| | *Guaranteed* | | *40.70* |
| 3856* | High Grade Bone and Bl. Meal | H. Postlethwaite, Lindsay | 43.34 |
| 3857* | High Grade Bone and Bl. Meal | H. Postlethwaite, Lindsay | 43.53 |
| 3858* | High Grade Bone and Bl. Meal | H. Postlethwaite, Lindsay | 43.92 |
| | *Guaranteed* | | *40.80* |
| 3866* | High Grade Bone and Bl. Meal | Merriman Fruit L. & L. Co., Exeter | 44.58 |
| | *Guaranteed* | | *42.80* |
| 3829 | Odorless Lawn | Hanson & Seares, Upland | 30.95 |
| | *Guaranteed* | | *21.80* |
| 4085 | Special | Fancher Creek Nurseries, Fresno | 39.38 |
| | *Guaranteed* | | *30.97* |
| 4157 | Special | Hammon Orchards, Oroville | 33.39 |
| | *Guaranteed* | | *33.34* |
| 4147 | Special Nitrogen | Security Investment Co., Palermo | 32.23 |
| | *Guaranteed* | | *31.24* |
| 4232 | Special Nitrogen | H. Postlethwaite, Lindsay | 32.84 |
| | *Guaranteed* | | *32.34* |
| 3647 | Special Nursery Stock | R. T. Godfrey, Riverside | 30.20 |
| 4075 | Special Nursery Stock | A. G. Schulz, Porterville | 28.53 |
| 4088 | Special Nursery Stock | A. C. Dungan, Exeter | 28.44 |
| 4089 | Special Nursery Stock | Merriman Fruit L. & L. Co., Exeter | 28.65 |
| 4149 | Special Nursery Stock | Security Investment Co., Palermo | 29.49 |
| | *Guaranteed* | | *28.78* |
| 4148 | Special Olive | Security Investment Co., Palermo | 28.00 |
| | *Guaranteed* | | *29.62* |
| 3701 | Special Orange A | Hanson & Seares, Upland | 28.84 |
| | *Guaranteed* | | *27.53* |
| 3648 | Special Orange and Lemon | R. T. Godfrey, Riverside | 29.16 |
| 4090 | Special Orange and Lemon | T. J. Dofflemyer & Sons, Exeter | 28.43 |
| | *Guaranteed* | | *28.51* |
| 4155 | Special Orange and Lemon | Security Investment Co., Palermo | 28.87 |
| | *Guaranteed* | | *28.17* |
| 3703 | Special Orange Tree | Hanson & Seares, Upland | 27.85 |
| 4074 | Special Orange Tree | A. G. Schulz, Porterville | 26.65 |

*3702—71% fine.
*3646—66% fine.
*3704—83% fine.
*3856—50% fine.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 3705 | ..... | ..... | ..... | ..... | ..... | ..... | 13.05 | ..... | 13.05 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *11.51* | ..... | *11.51* | ..... | ..... | ..... |
| 3702 | ..... | ..... | 23.50 | ..... | ..... | ..... | 2.83 | ..... | 2.83 | ..... | ..... | ..... |
| ..... | ..... | ..... | *20.00* | ..... | ..... | ..... | *2.50* | ..... | *2.50* | ..... | ..... | ..... |
| 4103 | 7.20 | 2.80 | 10.00 | ..... | 0.82 | 0.30 | 1.70 | ..... | 2.82 | 6.42 | 6.42 | ..... |
| ..... | *6.00* | *3.50* | *9.50* | *Super,* | *0.75* | ..... | *2.00* | *Bl, Bn* | *2.75* | *6.00* | *6.00* | ..... |
| 3899 | 7.02 | 2.78 | 9.80 | ..... | 0.69 | 0.30 | 1.44 | ..... | 2.43 | 7.18 | 7.18 | 0.60 |
| ..... | *6.00* | *3.00* | *9.00* | *Bn Super* | *0.50* | ..... | *2.00* | *Bl, Bn* | *2.50* | *7.15* | *7.15* | ..... |
| 3646 | ..... | ..... | 24.70 | ..... | ..... | ..... | 4.16 | ..... | 4.16 | ..... | ..... | ..... |
| 3704 | ..... | ..... | 24.20 | ..... | ..... | ..... | 4.14 | ..... | 4.14 | ..... | ..... | ..... |
| ..... | ..... | ..... | *22.00* | *Bn* | ..... | ..... | *4.10* | *Bl, Bn* | *4.10* | ..... | ..... | ..... |
| 3856 | ..... | ..... | 20.50 | ..... | ..... | ..... | 5.01 | ..... | 5.01 | ..... | ..... | ..... |
| 3857 | ..... | ..... | 20.10 | ..... | ..... | ..... | 5.14 | ..... | 5.14 | ..... | ..... | ..... |
| 3858 | ..... | ..... | 20.40 | ..... | ..... | ..... | 5.16 | ..... | 5.16 | ..... | ..... | ..... |
| ..... | ..... | ..... | *18.00* | *Bn* | ..... | ..... | *5.00* | *Bl, Bn* | *5.00* | ..... | ..... | ..... |
| 3866 | ..... | ..... | 20.55 | ..... | ..... | ..... | 5.27 | ..... | 5.27 | ..... | ..... | ..... |
| ..... | ..... | ..... | *20.00* | *Bn* | ..... | ..... | *5.00* | *Bl, Bn* | *5.00* | ..... | ..... | ..... |
| 3829 | **7.95** | 3.80 | 11.75 | ..... | 1.47 | 0.55 | 2.22 | ..... | 4.24 | 2.69 | 2.69 | ..... |
| ..... | *9.00* | *3.00* | *12.00* | *Super,* | ..... | ..... | *1.65* | *Bl, Bn* | *1.65* | *2.00* | *2.00* | ..... |
| 4085 | 4.49 | 1.76 | 6.25 | ..... | 0.75 | 0.30 | 4.50 | ..... | 5.55 | 8.27 | **8.27** | 0.75 |
| ..... | *5.50* | *3.00* | *8.50* | *Bn Super* | *1.50* | ..... | *1.50* | *Bl, Bn* | *3.00* | *10.00* | *10.00* | ..... |
| 4157 | 10.00 | 3.00 | 13.00 | ..... | 2.09 | 0.36 | 2.90 | ..... | 5.35 | ..... | ..... | ..... |
| ..... | *8.00* | *6.00* | *14.00* | *Bn Super* | *2.00* | ..... | *3.00* | *Bl, Bn* | *5.00* | ..... | ..... | ..... |
| 4147 | 4.22 | 0.88 | 5.10 | ..... | 6.52 | 1.18 | 0.20 | ..... | 7.90 | 3.17 | 3.17 | 0.70 |
| ..... | *3.40* | *1.10* | *4.50* | *Bn Black* | *7.00* | *1.00* | ..... | ..... | *8.00* | *3.00* | *3.00* | ..... |
| 4232 | 4.45 | 0.70 | 5.15 | ..... | 6.11 | 1.07 | ..... | ..... | 7.18 | 5.82 | 5.82 | 0.90 |
| ..... | *3.60* | *1.40* | *5.00* | *Bn Black* | *6.00* | *1.00* | ..... | ..... | *7.00* | *6.00* | *6.00* | ..... |
| 3647 | 7.07 | 3.68 | 10.75 | ..... | 1.07 | 0.20 | 2.51 | ..... | 3.78 | 3.74 | 3.74 | ..... |
| 4075 | 6.74 | 2.76 | 9.50 | ..... | 1.10 | 0.30 | 2.62 | ..... | 4.02 | 2.56 | 2.56 | 0.60 |
| 4088 | 6.86 | 3.04 | 9.90 | ..... | 1.10 | 0.25 | 2.65 | ..... | 4.00 | 2.17 | 2.17 | ..... |
| 4089 | 7.26 | 3.14 | 10.40 | ..... | 1.12 | 0.25 | 2.56 | ..... | 3.93 | 2.22 | 2.22 | ..... |
| 4149 | 6.50 | 2.80 | 9.30 | ..... | 1.10 | 0.35 | 2.85 | ..... | 4.30 | 2.50 | 2.50 | ..... |
| ..... | *7.00* | *3.00* | *10.00* | *Bn Super* | *1.00* | ..... | *3.00* | *Bl, Bn* | *4.00* | *2.00* | *2.00* | ..... |
| 4148 | **6.56** | 3.44 | 10.00 | ..... | 2.58 | 0.42 | 1.00 | ..... | 4.00 | 4.10 | 4.10 | ..... |
| ..... | *8.50* | *2.50* | *11.00* | *Super* | *2.40* | ..... | *1.60* | *Bl, Bn* | *4.00* | *4.00* | *4.00* | ..... |
| 3701 | 4.54 | 3.36 | 7.90 | ..... | ..... | 0.50 | 1.20 | ..... | 1.70 | 12.00 | 12.00 | 1.05 |
| ..... | *5.00* | *2.50* | *7.50* | *Super* | ..... | *0.50* | *1.00* | *Bl, Bn* | *1.50* | *12.00* | *12.00* | ..... |
| 3648 | 6.70 | 4.70 | 11.40 | ..... | 0.92 | 0.25 | 1.71 | ..... | 2.88 | 5.68 | 5.68 | ..... |
| 4090 | 6.75 | 2.60 | 9.35 | ..... | 0.89 | 0.20 | 2.21 | ..... | 3.30 | 5.06 | 5.06 | 0.90 |
| ..... | *6.00* | *4.00* | *10.00* | *Super* | *0.50* | ..... | *2.50* | *Bl, Bn* | *3.00* | *5.00* | *5.00* | ..... |
| 4155 | 6.28 | 3.72 | 10.00 | ..... | 0.83 | 0.20 | 2.05 | ..... | 3.08 | 5.68 | 5.68 | 0.80 |
| ..... | *6.00* | *4.00* | *10.00* | *Bn Super Super* | *0.70* | ..... | *2.30* | *Bl, Bn* | *3.00* | *5.00* | *5.00* | ..... |
| 3703 | 5.32 | 3.88 | 9.20 | ..... | 0.89 | 0.24 | 1.63 | ..... | 2.76 | 6.89 | 6.89 | 0.70 |
| 4074 | 6.31 | 2.24 | 8.55 | ..... | 0.75 | 0.35 | 1.55 | ..... | 2.65 | 6.74 | 6.74 | 0.60 |

*3857—50% fine.
*3858—46% fine.
*3866—63% fine.

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **California Fertilizer Works—** *Continued.* | | |
| 4154 | Special Orange Tree | Security Investment Co., Palermo | **25.11** |
| | *Guaranteed* | | *28.12* |
| 3706 | Sulfate of Potash | Hanson & Seares, Upland | **55.18** |
| | *Guaranteed* | | *55.86* |
| | **California Trading Co. Los Angeles, Cal.** | | |
| 4213* | Bone Meal | Factory, Los Angeles | 36.23 |
| | *Guaranteed* | | *34.56* |
| | **Chapman Fertilizer Co., Los Angeles, Cal.** | | |
| 3790 | Chapman's Fall | Sweetwater Fruit Co., Bonita | 36.99 |
| 3814 | Chapman's Fall | H. A. Brimmer, Rialto | 36.09 |
| 3825 | Chapman's Fall | H. J. Snead, San Dimas | 37.58 |
| | *Guaranteed* | | *35.10* |
| 3921 | Chapman's Spring | C. E. McLaughlin, Rialto | 38.76 |
| 3991 | Chapman's Spring | Francis Cuttle, Riverside | 39.69 |
| 4008 | Chapman's Spring | R. B. Campbell, Ontario | 39.37 |
| 4015 | Chapman's Spring | T. E. Moon, Colton | 41.06 |
| 4021 | Chapman's Spring | Francis Cuttle, Riverside | 40.33 |
| | *Guaranteed* | | *39.81* |
| | **C. J. Duff, Glendale, Cal.** | | |
| 3614* | Duff's Odorless Fertilizer | Factory, Glendale | ..... |
| | *Guaranteed* | | ..... |
| | **Federal Chemical Co., Los Angeles, Cal.** | | |
| 4199 | Special | J. G. Davidson, Los Angeles | 12.34 |
| | *Guaranteed* | | *10.54* |
| | **General Fertilizer Association, Los Angeles, Cal.** | | |
| 4167* | ..... | E. E. Speer, Glendora | 38.37 |
| | *Guaranteed* | | *39.81* |
| 3981 | Bat Guano | E. E. Raught, Redlands | 24.24 |
| | *Guaranteed* | | *21.92* |
| 4044 | Bat Guano | C. O. Baughman, Pomona | **20.75** |
| 4045 | Bat Guano | E. V. Decker, Pomona | **22.44** |
| | *Guaranteed* | | *26.64* |
| 4166 | Bat Guano | G. H. Wheeler, Rialto | ..... |
| | *Sold on Station Analysis.* | | |
| 3669 | Blood | J. D. Langford, Redlands | 56.88 |
| | *Guaranteed* | | *55.37* |

*4213—82% fine.

*3614—Chicken Manure and Nitrate of Soda.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 4154 | 5.70 | 2.40 | 8.10 | ..... | 0.74 | 0.42 | 1.52 | ..... | 2.68 | 5.69 | **5.69** | 0.70 |
| ..... | *6.00* | *3.50* | *9.50* | *Super* | *0.50* | ..... | *2.00* | *Bl, Bn* | *2.50* | *7.10* | *7.10* | ..... |
| 3706 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 48.40 | **48.40** | 1.83 |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | *49.00* | *49.00* | ..... |
| 4213 | ..... | ..... | 30.30 | ..... | ..... | ..... | 1.30 | ..... | 1.30 | ..... | ..... | ..... |
| ..... | ..... | ..... | *30.00* | ..... | ..... | ..... | *1.00* | ..... | *1.00* | ..... | ..... | ..... |
| 3790 | 14.36 | 3.24 | 17.60 | ..... | ..... | ..... | 0.95 | ..... | 0.95 | 13.21 | 13.21 | 0.88 |
| 3814 | ..... | ..... | 18.30 | ..... | ..... | ..... | 0.90 | ..... | 0.90 | 12.01 | 12.01 | ..... |
| 3825 | 14.24 | 4.96 | 19.20 | ..... | ..... | ..... | 1.15 | ..... | 1.15 | 11.53 | 11.53 | 0.60 |
| ..... | ..... | ..... | *18.00* | *Super, Bn* | ..... | ..... | *0.75* | *Bn* | *0.75* | *12.00* | *12.00* | ..... |
| 3921 | ..... | ..... | 10.25 | ..... | 1.82 | ..... | 5.13 | ..... | 6.95 | ..... | ..... | ..... |
| 3991 | ..... | ..... | 10.70 | ..... | 1.68 | ..... | 5.32 | ..... | 7.00 | ..... | ..... | ..... |
| 4008 | 6.33 | 4.32 | 10.65 | ..... | 2.10 | ..... | 5.00 | ..... | 7.10 | ..... | ..... | ..... |
| 4015 | ..... | ..... | 10.85 | ..... | 1.82 | ..... | 5.50 | ..... | 7.32 | ..... | ..... | ..... |
| 4021 | ..... | ..... | 10.65 | ..... | 1.99 | ..... | 5.50 | ..... | 7.49 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.50* | *Super, Bn, T* | *1.50* | ..... | *5.50* | *Bl, Bn, T* | *7.00* | ..... | ..... | ..... |
| 3614 | ..... | ..... | 0.90 | ..... | 1.39 | 0.15 | 0.46 | ..... | 2.00 | ..... | 0.39 | ..... |
| ..... | ..... | ..... | *0.65* | ..... | ..... | ..... | ..... | ..... | *1.48* | ..... | *0.52* | ..... |
| 4199 | 7.60 | 0.30 | 7.90 | ..... | 1.10 | ..... | ..... | ..... | 1.10 | 1.84 | 1.84 | ..... |
| ..... | *7.00* | ..... | ..... | *Super* | *1.00* | ..... | ..... | ..... | *1.00* | *1.00* | *1.00* | ..... |
| 4167 | **6.56** | 4.14 | 10.70 | ..... | 1.82 | 0.17 | 4.81 | ..... | 6.80 | ..... | ..... | ..... |
| ..... | *10.50* | ..... | ..... | *Super, Bn, T* | *1.50* | ..... | *5.50* | *Bl, Bn, T* | *7.00* | ..... | ..... | ..... |
| 3981 | ..... | ..... | 16.00 | ..... | 0.85 | ..... | **1.28** | ..... | 2.13 | ..... | ..... | ..... |
| ..... | ..... | ..... | *14.13* | ..... | ..... | ..... | ***1.71*** | ..... | *1.71* | ..... | ..... | ..... |
| 4044 | ..... | ..... | **14.10** | ..... | 0.73 | ..... | 1.01 | ..... | **1.74** | ..... | 0.40 | ..... |
| 4045 | ..... | ..... | **14.40** | ..... | 0.85 | ..... | **1.24** | ..... | **2.09** | ..... | 0.43 | ..... |
| ..... | ..... | ..... | *15.70* | ..... | ..... | ..... | ..... | ..... | *2.40* | ..... | *0.31* | ..... |
| 4166 | ..... | ..... | 10.00 | ..... | 1.23 | 0.20 | 2.72 | ..... | 4.15 | ..... | 0.58 | ..... |
| 3669 | ..... | ..... | ..... | ..... | ..... | ..... | 12.05 | ..... | 12.05 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *11.73* | ..... | *11.73* | ..... | ..... | ..... |

*4167—No brand name as required by Fertilizer Act.

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **General Fertilizer Association** —*Continued.* | | |
| 3798 | Blood | Limoneira Ranch, Santa Paula | |
| | *Sold on Station Analysis.* | | |
| 3915 | Blood | P. J. Bollinger, Riverside | 61.45 |
| | *Guaranteed* | | *55.69* |
| 4238 | Blood | Etiwanda Citrus Assn., Etiwanda | 65.13 |
| | *Guaranteed* | | *64.52* |
| 3878* | Bone Meal | F. A. Springstead, El Cajon | 35.57 |
| | *Guaranteed* | | *36.40* |
| 3913* | Bone Meal | P. J. Bollinger, Riverside | 37.85 |
| | *Guaranteed* | | *39.40* |
| 3686 | Chapman's Fall | Factory, Ontario | 36.51 |
| 3722 | Chapman's Fall | Francis, Cuttle, Riverside | 37.94 |
| 3726 | Chapman's Fall | C. E. McLaughlin, Rialto | 37.08 |
| 3751 | Chapman's Fall | W. D. Hoover, Rialto | 36.96 |
| 3764 | Chapman's Fall | R. C. Hoyt, Riverside | 38.19 |
| | *Guaranteed* | | *36.10* |
| 4042 | G. F. A. No. 2 | Mrs. M. A. Clemmons, Highland | **25.47** |
| 4237 | G. F. A. No. 2 | Etiwanda Citrus Assn., Etiwanda | 26.02 |
| | *Guaranteed* | | *28.45* |
| 3687 | G. F. A. No. 3 | Factory, Ontario | 24.62 |
| | *Guaranteed* | | *23.22* |
| 3855* | G. F. A. No. 3 | W. H. Truitt, Pomona | 24.00 |
| | *Guaranteed* | | *20.22* |
| 3845* | G. F. A. No. 4 | H. A. Barton, Orange | 29.60 |
| | *Guaranteed* | | *31.84* |
| 3847* | G. F. A. No. 5 | H. A. Barton, Orange | 37.13 |
| | *Guaranteed* | | *37.08* |
| 4062 | G. F. A. No. 5 | W. C. Fertig, Lindsay | 35.04 |
| | *Guaranteed* | | *34.47* |
| 3846* | G. F. A. No. 6 | H. A. Barton, Orange | 30.56 |
| | *Guaranteed* | | *32.52* |
| 3824 | G. F. A. No. 11 | J. Schwab, Ontario | 31.53 |
| | *Guaranteed* | | *32.25* |
| 3917 | G. F. A. No. 15 | P. J. Bollinger, Riverside | 35.03 |
| | *Guaranteed* | | *36.87* |
| 3844 | Guano | C. E. Bowlsby, Rialto | 25.63 |
| | *Guaranteed* | | *26.16* |
| 4061* | Lindsay Special | W. C. Fertig, Lindsay | 33.46 |
| | *Guaranteed* | | *34.39* |
| 4046 | Nitrate of Lime | Wright Bros., Riverside | 36.57 |
| | *Guaranteed* | | *36.66* |
| 3674 | Nitrate of Soda | Redlands Fertilizer Assn., Redlands | 42.84 |
| 3711 | Nitrate of Soda | Cucamonga C. F. G. Assn., Cucamonga | 43.15 |
| 3879 | Nitrate of Soda | F. A. Springstead, El Cajon | 43.28 |

*3878—64% fine.
*3913—55% fine.
*3855—Rock Phosphate present.
*3845—Derivations not guaranteed.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 3798 | ..... | ..... | ..... | ..... | ..... | ..... | 12.09 | ..... | 12.09 | ..... | ..... | ..... |
| 3915 | ..... | ..... | ..... | ..... | ..... | ..... | 13.02 | ..... | 13.02 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *11.80* | ..... | *11.80* | ..... | ..... | ..... |
| 4238 | ..... | ..... | ..... | ..... | ..... | ..... | 13.80 | ..... | 13.80 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.67* | ..... | *13.67* | ..... | ..... | ..... |
| 3878 | ..... | ..... | **22.30** | ..... | ..... | ..... | 2.91 | ..... | 2.91 | ..... | ..... | ..... |
| ..... | ..... | ..... | *25.00* | ..... | ..... | ..... | *2.50* | ..... | *2.50* | ..... | ..... | ..... |
| 3913 | ..... | ..... | **23.90** | ..... | ..... | ..... | 3.06 | ..... | 3.06 | ..... | ..... | ..... |
| ..... | ..... | ..... | *28.00* | ..... | ..... | ..... | *2.50* | ..... | *2.50* | ..... | ..... | ..... |
| 3686 | 13.54 | 7.86 | 21.40 | ..... | ..... | ..... | 0.65 | ..... | 0.65 | 10.66 | **10.66** | 0.80 |
| 3722 | 13.95 | 7.65 | 21.60 | ..... | ..... | ..... | 0.50 | ..... | 0.50 | 12.33 | 12.33 | ..... |
| 3726 | 14.36 | 7.04 | 21.40 | ..... | ..... | ..... | 0.52 | ..... | 0.52 | 11.68 | 11.68 | ..... |
| 3751 | 14.66 | 6.34 | 21.00 | ..... | ..... | ..... | 0.53 | ..... | 0.53 | 11.89 | 11.89 | 0.80 |
| 3764 | 14.78 | 6.62 | 21.40 | ..... | ..... | ..... | 0.50 | ..... | 0.50 | 12.75 | 12.75 | ..... |
| ..... | *12.50* | *6.50* | *19.00* | *Super, Bn* | ..... | ..... | *0.75* | *Bn* | *0.75* | *12.00* | *12.00* | ..... |
| 4042 | ..... | ..... | 10.35 | ..... | 2.37 | ..... | 1.35 | ..... | **3.72** | 2.00 | 2.00 | ..... |
| 4237 | 4.73 | 6.52 | 11.25 | ..... | 2.25 | ..... | 1.28 | ..... | **3.53** | 2.27 | 2.27 | ..... |
| ..... | ..... | ..... | *10.00* | *Bn, G* | *1.50* | ..... | *2.62* | *Bl, Bn, G* | *4.12* | *2.00* | *2.00* | ..... |
| 3687 | 6.42 | 4.88 | 11.30 | ..... | 0.47 | 0.15 | 1.45 | ..... | 2.07 | 4.25 | **4.25** | ..... |
| ..... | *7.00* | *3.00* | *10.00* | *Super, Bn, G* | ..... | ..... | *1.65* | *Bl, Bn, G* | *1.65* | *5.00* | *5.00* | ..... |
| 3855 | 10.30 | 8.50 | 18.80 | ..... | 1.06 | 0.10 | 1.06 | ..... | 2.22 | 4.84 | 4.84 | ..... |
| ..... | *7.00* | *3.00* | *10.00* | *Super, Bn, G* | ..... | ..... | *1.65* | *Bl, Bn, G* | *1.65* | *5.00* | *5.00* | ..... |
| 3845 | 7.05 | 2.80 | 9.85 | ..... | 1.55 | ..... | 1.40 | ..... | 2.95 | 7.90 | 7.90 | 0.75 |
| ..... | *7.00* | *2.50* | *9.50* | ..... | ..... | ..... | ..... | ..... | *2.90* | *8.00* | *8.00* | ..... |
| 3847 | **6.63** | 5.12 | 11.75 | ..... | 2.15 | 0.15 | 3.30 | ..... | 5.60 | ..... | 3.28 | 1.20 |
| ..... | *8.00* | *4.00* | *12.00* | ..... | ..... | ..... | ..... | ..... | *5.00* | ..... | *2.00* | ..... |
| 4062 | 11.15 | 4.30 | 15.45 | ..... | 2.42 | 0.15 | 1.91 | ..... | **4.48** | ..... | 3.09 | 1.00 |
| ..... | *8.00* | *4.00* | *12.00* | *Super, Bn* | *1.50* | ..... | *3.50* | *Bl, Bn* | *5.00* | ..... | *2.00* | ..... |
| 3846 | 8.74 | 3.16 | 11.90 | ..... | 1.76 | ..... | 1.56 | ..... | 3.32 | 5.78 | 5.78 | 0.70 |
| ..... | *8.00* | *4.00* | *12.00* | ..... | ..... | ..... | ..... | ..... | *3.00* | *6.00* | *6.00* | ..... |
| 3824 | 11.58 | 7.22 | 18.80 | ..... | ..... | ..... | 1.25 | ..... | 1.25 | 6.17 | 6.17 | 0.65 |
| ..... | *12.00* | *6.00* | *18.00* | *Bn, G* | ..... | ..... | *1.50* | *Bl, Bn, G* | *1.50* | *6.50* | *6.50* | ..... |
| 3917 | 14.30 | 5.50 | 19.80 | ..... | ..... | ..... | 0.96 | ..... | 0.96 | 9.52 | 9.52 | ..... |
| ..... | *12.00* | *8.00* | *20.00* | *Bat G, Bn* | ..... | ..... | *1.20* | *Bat G, Bn* | *1.20* | *10.00* | *10.00* | ..... |
| 3844 | ..... | ..... | 18.40 | ..... | 0.69 | ..... | 1.16 | ..... | 1.85 | ..... | 0.54 | ..... |
| ..... | ..... | ..... | *18.82* | ..... | ..... | ..... | *1.61* | ..... | *1.61* | ..... | *0.80* | ..... |
| 4061 | 7.82 | 1.68 | 9.50 | ..... | ..... | ..... | 3.91 | ..... | **3.91** | ..... | 5.38 | 1.20 |
| ..... | *8.50* | *1.50* | *10.00* | ..... | ..... | ..... | *4.35* | ..... | *4.35* | ..... | *4.00* | ..... |
| 4046 | ..... | ..... | ..... | ..... | 12.97 | ..... | ..... | ..... | 12.97 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | 13.00 | ..... | ..... | ..... | 13.00 | ..... | ..... | ..... |
| 3674 | ..... | ..... | ..... | ..... | 15.19 | ..... | ..... | ..... | 15.19 | ..... | ..... | ..... |
| 3711 | ..... | ..... | ..... | ..... | 15.30 | ..... | ..... | ..... | 15.30 | ..... | ..... | ..... |
| 3879 | ..... | ..... | ..... | ..... | 15.35 | ..... | ..... | ..... | 15.35 | ..... | ..... | ..... |

*3847—Derivations not guaranteed.

*3846—Derivations not guaranteed.

*4061—Derivations not guaranteed.

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **General Fertilizer Association** —*Continued.* | | |
| 4174 | Nitrate of Soda | Fontana Development Co., Rialto | 44.02 |
| | *Guaranteed* | | *42.30* |
| 3619 | Orange and Lemon No. 1 | Gordon Nelson, Byrn Mawr | 32.51 |
| | *Guaranteed* | | *30.46* |
| 3673* | Orange and Lemon No. 1 | Redlands Fertilizer Assn., Redlands | 32.70 |
| | *Guaranteed* | | *33.94* |
| 3715 | Orange and Lemon No. 1 | Cucamonga C. F. G. Assn., Cucamonga | 34.47 |
| | *Guaranteed* | | *31.33* |
| 3947 | Orange and Lemon No. 1 | Redlands Fertilizer Assn., Redlands | 30.46 |
| | *Guaranteed* | | *31.15* |
| 3955 | Orange and Lemon No. 1 | Fred Hiser, Colton | **28.53** |
| | *Guaranteed* | | *31.54* |
| 3819 | San Dimas | L. S. Taylor, San Dimas | 34.30 |
| | *Guaranteed* | | *32.10* |
| 3666* | Special | Redlands Fertilizer Assn., Redlands | 34.82 |
| | *Guaranteed* | | *35.36* |
| 3667* | Special | Redlands Fertilizer Assn., Redlands | 32.45 |
| | *Guaranteed* | | *32.52* |
| 3670* | Special | J. D. Langford, Redlands | 31.68 |
| | *Guaranteed* | | *32.47* |
| 3671* | Special | J. D. Langford, Redlands | **30.31** |
| | *Guaranteed* | | *34.75* |
| 3672* | Special | J. D. Langford, Redlands | **31.91** |
| | *Guaranteed* | | *37.36* |
| 3713* | Special | W. F. Grow, Highland | 32.58 |
| | *Guaranteed* | | *32.52* |
| 4003 | Special | D. B. Lee, Ontario | 46.62 |
| | *Guaranteed* | | *45.92* |
| 4022 | Special | C. A. Crosby, Riverside | **27.15** |
| 4023 | Special | C. A. Crosby, Riverside | 31.59 |
| 4024 | Special | C. A. Crosby, Riverside | 30.01 |
| | *Guaranteed* | | *31.60* |
| 4164 | Special | C. H. Clock, Redlands | 34.72 |
| | *Guaranteed* | | *36.44* |
| 4171* | Special | Fontana Development Co., Rialto | 44.05 |
| | *Guaranteed* | | *49.77* |
| 4195 | Special | Tustin Lemon Association, Tustin | **26.57** |
| 4198 | Special | Tustin Lemon Association, Tustin | **30.54** |
| | *Guaranteed* | | *33.44* |
| 4196 | Special | Tustin Lemon Association, Tustin | 23.22 |
| | *Guaranteed* | | *23.36* |

*3673—Derivations not guaranteed.

*3955—Derivations not guaranteed. Discrepancy in valuation due to inadequacy of guaranty.

*3666—Derivations not guaranteed.

*3667—Derivations not guaranteed.

*3670—Derivations not guaranteed.

*3671—Derivations not guaranteed.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 4174 | ..... | ..... | ..... | ..... | 15.61 | ..... | ..... | ..... | 15.61 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... |
| 3619 | 7.16 | 5.64 | 12.80 | ..... | 1.89 | ..... | 2.06 | ..... | 3.95 | 4.38 | **4.38** | 0.77 |
| ..... | *5.00* | *5.00* | *10.00* | *Super, Bn* | *2.00* | ..... | *2.00* | *Bl, Bn, G* | *4.00* | *5.00* | *5.00* | ..... |
| 3673 | 6.14 | 4.46 | 10.60 | ..... | 1.72 | 0.10 | 2.21 | ..... | 4.03 | 6.02 | 6.02 | 0.92 |
| ..... | *6.00* | *4.00* | *10.00* | ..... | ..... | ..... | ..... | ..... | *4.00* | *5.00* | *5.00* | ..... |
| 3715 | 9.13 | 4.22 | 13.35 | ..... | 2.46 | 0.34 | 1.45 | ..... | 4.25 | 5.57 | 5.57 | 0.75 |
| ..... | *6.00* | *4.00* | *10.00* | *Super, Bn, G* | *1.50* | ..... | *2.50* | *Bl, Bn, G* | *4.00* | *5.00* | *5.00* | ..... |
| 3947 | 5.49 | 5.56 | 11.05 | ..... | 1.78 | ..... | 1.80 | ..... | **3.58** | 5.43 | 5.43 | 0.80 |
| ..... | *6.00* | *4.00* | *10.00* | *Bn, G* | *1.60* | ..... | *2.40* | *Bn, G* | *4.00* | *5.00* | *5.00* | ..... |
| 3955 | 5.34 | 5.36 | 10.70 | ..... | 1.62 | ..... | 2.33 | ..... | 3.95 | 4.57 | 4.57 | 0.75 |
| ..... | *6.00* | *4.00* | *10.00* | ..... | ..... | ..... | *4.00* | ..... | *4.00* | *5.00* | *5.00* | ..... |
| 3819 | ..... | ..... | 17.25 | ..... | ..... | ..... | 1.00 | ..... | 1.00 | 10.96 | 10.96 | ..... |
| ..... | ..... | ..... | *15.00* | *Bn* | ..... | ..... | *1.25* | *Bl, Bn* | *1.25* | *10.00* | *10.00* | ..... |
| 3666 | 6.20 | 3.30 | 9.50 | ..... | 1.71 | 0.10 | 2.24 | ..... | 4.05 | 8.71 | 8.71 | 0.88 |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | ..... | ..... | *4.00* | *8.00* | *8.00* | ..... |
| 3667 | 7.15 | 5.60 | 12.75 | ..... | 1.06 | 0.10 | 2.04 | ..... | 3.20 | 6.18 | 6.18 | 0.75 |
| ..... | ..... | ..... | *12.00* | ..... | ..... | ..... | ..... | ..... | *3.00* | *6.00* | *6.00* | ..... |
| 3670 | 5.77 | 5.28 | 11.05 | ..... | 1.87 | 0.20 | 2.70 | ..... | 4.77 | 2.04 | 2.04 | 0.75 |
| ..... | *6.00* | *4.00* | *10.00* | ..... | *1.50* | ..... | *3.50* | ..... | *5.00* | *2.00* | *2.00* | ..... |
| 3671 | 6.79 | 3.96 | 10.75 | ..... | 1.61 | 0.10 | 2.15 | ..... | **3.86** | 4.26 | 4.26 | 0.80 |
| ..... | *6.00* | *4.00* | *10.00* | ..... | *1.50* | ..... | *3.50* | ..... | *5.00* | *4.00* | *4.00* | ..... |
| 3672 | ..... | ..... | 9.20 | ..... | 2.27 | 0.10 | 2.40 | ..... | 4.77 | ..... | 4.38 | 1.00 |
| ..... | ..... | ..... | *10.00* | ..... | ..... | ..... | ..... | ..... | *5.00* | ..... | *4.00* | ..... |
| 3713 | ..... | ..... | 12.60 | ..... | 0.50 | 0.10 | 2.82 | ..... | 3.42 | 4.69 | 4.69 | ..... |
| ..... | ..... | ..... | *12.00* | ..... | ..... | ..... | ..... | ..... | *3.50* | *4.00* | *4.00* | ..... |
| 4003 | 8.73 | 4.52 | 13.25 | ..... | ..... | ..... | 6.11 | ..... | 6.11 | ..... | 4.84 | 1.60 |
| ..... | *6.50* | *7.50* | *14.00* | *Bn, T* | ..... | ..... | *6.00* | *Bn, T* | *6.00* | *4.00* | *4.00* | ..... |
| 4022 | ..... | ..... | **8.80** | ..... | 1.80 | 0.30 | 2.08 | ..... | **4.18** | 2.40 | 2.40 | ..... |
| 4023 | ..... | ..... | 10.90 | ..... | 1.73 | ..... | 2.75 | ..... | **4.48** | 2.88 | 2.88 | ..... |
| 4024 | ..... | ..... | 9.80 | ..... | 1.84 | 0.20 | 2.50 | ..... | **4.54** | 2.55 | 2.55 | ..... |
| ..... | ..... | ..... | *10.00* | *Bn, G* | *2.00* | ..... | *3.00* | *Bl, Bn, G* | *5.00* | *2.00* | *2.00* | ..... |
| 4164 | ..... | ..... | 7.30 | ..... | 1.92 | 0.15 | 3.60 | ..... | **5.67** | ..... | 4.44 | 1.62 |
| ..... | ..... | ..... | *8.00* | *Bn, G* | *2.00* | ..... | *4.00* | *Bl, Bn, G* | *6.00* | *4.00* | *4.00* | ..... |
| 4171 | 9.90 | 2.00 | 11.90 | ..... | 1.77 | 1.65 | 3.03 | ..... | 6.45 | 6.54 | 6.54 | 0.75 |
| ..... | *5.10* | *7.37* | *12.47* | *Bn, G* | ..... | ..... | ..... | *Bl, Bn, G* | *6.68* | *6.00* | *6.00* | ..... |
| 4195 | **4.95** | 4.20 | 9.15 | ..... | 2.35 | ..... | 1.70 | ..... | **4.05** | 2.67 | 2.67 | ..... |
| 4198 | **4.33** | 6.72 | 11.05 | ..... | 2.16 | ..... | 2.12 | ..... | 4.28 | 3.27 | 3.27 | ..... |
| ..... | *8.00* | *4.00* | *12.00* | *Super, Bn, G* | *1.50* | ..... | *3.00* | *Bl, Bn, G* | *4.50* | *3.10* | *3.10* | ..... |
| 4196 | 13.70 | 0.40 | 14.10 | ..... | 2.12 | ..... | ..... | ..... | 2.12 | 3.83 | 3.83 | ..... |
| ..... | *14.00* | *1.00* | *15.00* | *Super* | *2.00* | ..... | ..... | ..... | *2.00* | *4.00* | *4.00* | ..... |

*3672—Derivations not guaranteed. Discrepancy in valuation due to inadequacy of guaranty.

*3713—Derivations not guaranteed.

*4171—Discrepancy in valuation due to inadequacy of guaranty.

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **General Fertilizer Association** —*Continued.* | | |
| 4197 | Special | Tustin Lemon Association, Tustin | 32.15 |
| | *Guaranteed* | | *31.38* |
| 4221 | Special | C. L. Clock, Redlands | **32.52** |
| | *Guaranteed* | | *37.31* |
| 3712 | Special No. 2 | Cucamonga C. F. G. Assn., Cucamonga | 31.11 |
| | *Guaranteed* | | *28.46* |
| 3916* | Special Orange | P. J. Bollinger, Riverside | **32.10** |
| | *Guaranteed* | | *36.05* |
| 3954 | Special Orange | Fred Hiser, Colton | 48.78 |
| | *Guaranteed* | | *48.64* |
| 3963* | Special Orange | J. E. Schermerhorn, Colton | 32.64 |
| | *Guaranteed* | | *35.34* |
| 4004 | Special Orange | Bemis Bros. & McCullough, Rialto | 35.45 |
| | *Guaranteed* | | *34.16* |
| 3996* | Special Orange and Lemon No. 1 | E. A. Bemis, Rialto | **31.36** |
| 3997* | Special Orange and Lemon No. 1 | E. A. Bemis, Rialto | 34.35 |
| | *Guaranteed* | | *37.00* |
| 3817* | Special Orange No. 15 | B. E. Sibley, Rialto | 36.61 |
| | *Guaranteed* | | *36.87* |
| 4173 | Sulfate of Potash | Fontana Development Co., Rialto | 56.04 |
| | *Guaranteed* | | *55.86* |
| 3903 | Superphosphate | H. D. Derwin, Upland | ..... |
| | *Sold on Station Analysis.* | | |
| 4048 | Superphosphate | F. D. Parker, Hollywood | 20.02 |
| | *Guaranteed* | | *21.86* |
| 4172 | Superphosphate | Fontana Development Co., Rialto | **21.19** |
| | *Guaranteed* | | *22.56* |
| 3799* | Tankage | Limoneira Ranch, Santa Paula | ..... |
| 3800* | Tankage | Limoneira Ranch, Santa Paula | ..... |
| | *Sold on Station Analysis.* | | |
| 3914* | Tankage | P. J. Bollinger, Riverside | 46.26 |
| | *Guaranteed* | | *44.08* |
| 4043* | Tankage | R. C. Hoyt, Riverside | 49.65 |
| | *Guaranteed* | | *49.23* |
| 4200* | Tankage | C. C. Chapman, Fullerton | 44.32 |
| | *Guaranteed* | | *42.69* |
| 4194 | Tankage and Bat Guano | Tustin Lemon Assn., Tustin | **35.56** |
| | *Guaranteed* | | *38.78* |
| 3861 | Whittier Citrus | Whittier Citrus Assn., Whittier | 42.98 |
| | *Guaranteed* | | *40.52* |

* 3916—Derivations not guaranteed. Discrepancy in valuation due to inadequacy of guaranty.

*3963—Derivations not guaranteed.

*3996—Derivations not guaranteed. Discrepancy in valuation due to inadequacy of guaranty.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 4197 | 6.20 | 7.10 | 13.30 | ..... | 1.63 | ..... | 1.65 | ..... | 3.28 | 5.90 | 5.90 | ..... |
| ..... | *7.00* | *5.00* | *12.00* | *Super, Bn, G* | ..... | ..... | ..... | *Bl, Bn, G* | *3.00* | *5.00* | *5.00* | ..... |
| 4221 | ..... | ..... | 7.50 | ..... | 2.38 | ..... | 3.00 | ..... | **5.38** | ..... | 4.06 | 1.60 |
| ..... | ..... | ..... | *8.00* | *Bn, G* | *1.50* | ..... | *4.50* | *Bl, Bn, G* | *6.00* | *4.00* | *4.00* | ..... |
| 3712 | 8.04 | 4.96 | 13.00 | ..... | 2.44 | 0.30 | 1.56 | ..... | 4.30 | 2.68 | 2.68 | 0.77 |
| ..... | *7.00* | *3.00* | *10.00* | *Super, Bn, G* | *1.50* | ..... | *2.62* | *Bl, Bn, G* | *4.12* | *2.00* | *2.00* | ..... |
| 3916 | 6.55 | 3.80 | **10.35** | ..... | 1.58 | 0.10 | 2.97 | ..... | 4.65 | 2.98 | 2.98 | ..... |
| ..... | ..... | ..... | *12.00* | ..... | ..... | ..... | ..... | ..... | *4.50* | *3.10* | *3.10* | ..... |
| 3954 | ..... | ..... | 5.20 | ..... | ..... | ..... | 8.45 | ..... | **8.45** | 5.53 | 5.53 | ..... |
| ..... | ..... | ..... | *1.00* | *T* | ..... | ..... | *9.00* | *T* | *9.00* | *6.00* | *6.00* | ..... |
| 3963 | ..... | ..... | 13.65 | ..... | 2.07 | ..... | 3.75 | ..... | 4.82 | ..... | 3.41 | 1.20 |
| ..... | ..... | ..... | *12.00* | ..... | ..... | ..... | ..... | ..... | *5.00* | *3.00* | *3.00* | ..... |
| 4004 | ..... | ..... | 8.75 | ..... | 1.99 | 0.20 | 3.76 | ..... | 5.95 | ..... | 2.83 | 1.50 |
| ..... | ..... | ..... | *8.00* | *Bn, G* | *2.00* | ..... | *4.00* | G. T | *6.00* | ..... | *2.00* | ..... |
| 3996 | ..... | ..... | 8.75 | ..... | 2.09 | 0.20 | 2.91 | ..... | **5.20** | ..... | 3.01 | 1.40 |
| 3997 | ..... | ..... | 8.75 | ..... | 2.16 | 0.20 | 3.75 | ..... | 6.11 | ..... | 2.10 | 1.65 |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | ..... | ..... | *6.00* | *2.00* | *2.00* | ..... |
| 3817 | 14.08 | 8.12 | 22.20 | ..... | ..... | ..... | 0.97 | ..... | 0.97 | 8.76 | **8.76** | ..... |
| ..... | *12.00* | *8.00* | *20.00* | ..... | ..... | ..... | ..... | ..... | *1.20* | *10.00* | *10.00* | ..... |
| 4173 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 49.16 | 49.16 | 1.50 |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | *49.00* | *49.00* | ..... |
| 3903 | 21.40 | 0.30 | 21.70 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4048 | 22.36 | 0.34 | 22.70 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *23.25* | *1.07* | *24.32* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4172 | 22.54 | 0.36 | **22.90** | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | ..... | ..... | *24.00* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3799 | ..... | ..... | 6.15 | ..... | ..... | ..... | 8.28 | ..... | 8.28 | ..... | ..... | ..... |
| 3800 | ..... | ..... | 7.85 | ..... | ..... | ..... | 8.46 | ..... | 8.46 | ..... | ..... | ..... |
| 3914 | ..... | ..... | 11.55 | ..... | ..... | ..... | 8.22 | ..... | 8.22 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | *Bn* | ..... | ..... | *8.00* | *Bl, Bn* | *8.00* | ..... | ..... | ..... |
| 4043 | ..... | ..... | 5.70 | ..... | ..... | ..... | 9.94 | ..... | 9.94 | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.50* | *Bn* | ..... | ..... | *9.88* | *Bl, Bn* | *9.88* | ..... | ..... | ..... |
| 4200 | ..... | ..... | 6.60 | ..... | ..... | ..... | 8.62 | ..... | 8.62 | ..... | ..... | ..... |
| ..... | ..... | ..... | *6.86* | *Bn* | ..... | ..... | *8.22* | *Bl, Bn* | *8.22* | ..... | ..... | ..... |
| 4194 | **4.06** | 4.44 | 8.50 | ..... | 1.05 | 0.30 | 5.05 | ..... | **6.40** | ..... | ..... | ..... |
| ..... | *6.00* | *2.00* | *8.00* | ..... | ..... | ..... | *6.75* | ..... | *6.75* | ..... | ..... | ..... |
| 3861 | ..... | ..... | 22.10 | ..... | ..... | ..... | *2.00* | *Bn* | *2.00* | *10.00* | *10.00* | ..... |
| ..... | ..... | ..... | *20.00* | *Bn,* | ..... | ..... | 2.18 | ..... | 2.18 | 9.60 | 9.60 | 0.80 |

*3997—Derivations not guaranteed. Discrepancy in valuation due to inadequacy of guaranty.

*3817—Derivations not guaranteed.

*3799—64% fine.

*3800—62% fine.

*3914—73% fine.

*4043—66% fine.

*4200—63% fine.

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Hauser Packing Co., Los Angeles, Cal.** | | |
| 3998 | Blood | Fitzgerald & Barry, Los Angeles | ..... |
| | *Sold on Station Analysis.* | | |
| 3886* | Tankage | Benchley Fruit Co., Fullerton | 40.85 |
| | *Guaranteed* | | *40.96* |
| 3894 | Tankage | C. H. Clock, Redlands | ..... |
| 3895* | Tankage | C. H. Clock, Redlands | ..... |
| 3959* | Tankage | C. L. Clock, Redlands | ..... |
| 3976* | Tankage | H. Latimer, Arlington | ..... |
| 4005* | Tankage | H. Latimer, Arlington | ..... |
| 4006* | Tankage | H. Latimer, Arlington | ..... |
| 4007* | Tankage | H. Latimer, Arlington | ..... |
| 4020* | Tankage | Sugar Loaf O. G. Assn., Highgrove | ..... |
| | *Sold on Station Analysis.* | | |
| | **Hawaiian Fertilizer Co., San Francisco Cal.** | | |
| 4064 | Nitrate of Soda | W. E. Porter, Lindsay | 43.68 |
| | *Guaranteed* | | *42.30* |
| 4117* | Slag | M. Braughler, Santa Rosa | 13.44 |
| | *Guaranteed* | | *13.44* |
| 4063* | Special | W. E. Porter, Lindsay | 35.55 |
| | *Guaranteed* | | *38.21* |
| 4188* | Special | W. R. Burch, San Francisco | **17.27** |
| | *Guaranteed* | | *20.80* |
| 4245* | Special | W. R. Burch, San Francisco | 22.05 |
| | *Guaranteed* | | *21.90* |
| 4189* | Superphosphate | W. R. Burch, San Francisco | **11.97** |
| | *Guaranteed* | | *15.98* |
| | **Thomas Lewis, Sacramento, Cal.** | | |
| 4128* | Tom Lewis | J. S. Morrow, Fair Oaks | 5.35 |
| | *Guaranteed* | | *6.00* |
| | **Los Angeles Fertilizer Co., Los Angeles, Cal.** | | |
| 3749 | Bone and Potash | J. D. McClenny, Pomona | 35.30 |
| 3774 | Bone and Potash | E. F. Wilson, Upland | 34.55 |
| | *Guaranteed* | | *35.10* |
| 3750 | Bone and Potash | J. D. McClenny, Pomona | **42.96** |
| | *Guaranteed* | | *45.81* |

*3886—46% fine.
*3894—62% fine. Some hoof.
*3895—69% fine. Some hoof.
*3959—75% fine.
*3976—56% fine.
*4005—61% fine.
*4006—63% fine.
*4007—63% fine.
*4020—63% fine. Some hoof.
*4117—A mixture of Thomas Slag and Superphosphate.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 3998 | ..... | ..... | ..... | ..... | ..... | ..... | 12.28 | ..... | 12.28 | ..... | ..... | ..... |
| 3886 | ..... | ..... | 12.55 | ..... | ..... | ..... | 6.87 | ..... | **6.87** | ..... | ..... | ..... |
| ..... | ..... | ..... | *9.50* | ..... | ..... | ..... | *7.40* | ..... | *7.40* | ..... | ..... | ..... |
| 3894 | ..... | ..... | 14.05 | ..... | ..... | ..... | 5.89 | ..... | 5.89 | ..... | ..... | ..... |
| 3895 | ..... | ..... | 10.65 | ..... | ..... | ..... | 6.20 | ..... | 6.20 | ..... | ..... | ..... |
| 3959 | ..... | ..... | 10.20 | ..... | ..... | ..... | 6.98 | ..... | 6.98 | ..... | ..... | ..... |
| 3976 | ..... | ..... | 8.50 | ..... | ..... | ..... | 6.41 | ..... | 6.41 | ..... | ..... | ..... |
| 4005 | ..... | ..... | 11.90 | ..... | ..... | ..... | 6.17 | ..... | 6.17 | ..... | ..... | ..... |
| 4006 | ..... | ..... | 11.90 | ..... | ..... | ..... | 6.69 | ..... | 6.69 | ..... | ..... | ..... |
| 4007 | ..... | ..... | 13.40 | ..... | ..... | ..... | 6.50 | ..... | 6.50 | ..... | ..... | ..... |
| 4020 | ..... | ..... | 13.40 | ..... | ..... | ..... | 6.53 | ..... | 6.53 | ..... | ..... | ..... |
| 4064 | ..... | ..... | ..... | ..... | 15.49 | ..... | ..... | ..... | 15.49 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... |
| 4117 | 8.20 | 7.80 | 16.00 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | ..... | ..... | *16.00* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4063 | 9.34 | 1.16 | 10.50 | ..... | 2.00 | 2.67 | 1.46 | ..... | 6.13 | 2.81 | 2.81 | ..... |
| ..... | *8.00* | ..... | ..... | *Super, Bn, G* | ..... | ..... | ..... | *Bn, G, T* | *6.00* | *2.50* | *2.50* | ..... |
| 4188 | 6.34 | 3.76 | 10.10 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 9.93 | 4.45 |
| ..... | ..... | ..... | *10.00* | *Super* | ..... | ..... | ..... | ..... | ..... | *10.00* | *10.00* | ..... |
| 4245 | ..... | ..... | 12.60 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 10.06 | 3.00 |
| ..... | ..... | ..... | *12.50* | *T. P. P.* | ..... | ..... | ..... | ..... | ..... | *10.00* | *10.00* | ..... |
| 4189 | 12.74 | 4.06 | 16.80 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | ..... | ..... | *17.00* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4128 | ..... | ..... | 1.70 | ..... | ..... | ..... | 0.80 | ..... | 0.80 | ..... | 0.33 | ..... |
| ..... | ..... | ..... | *1.63* | ..... | ..... | ..... | *0.96* | ..... | *0.96* | ..... | *0.21* | ..... |
| 3749 | ..... | ..... | 19.20 | ..... | ..... | ..... | 2.11 | ..... | 2.11 | 5.70 | **5.70** | ..... |
| 3774 | ..... | ..... | 17.30 | ..... | ..... | ..... | 2.06 | ..... | 2.06 | 6.90 | 6.90 | 0.60 |
| ..... | ..... | ..... | *18.00* | *Bn* | ..... | ..... | *2.00* | *Bn* | *2.00* | *7.00* | *7.00* | ..... |
| 3750 | ..... | ..... | **9.65** | ..... | ..... | ..... | 1.09 | ..... | 1.09 | 24.86 | **24.86** | 0.75 |
| ..... | ..... | ..... | *10.85* | *Super, Bn, T* | ..... | ..... | *1.10* | *Bn, T* | *1.10* | *26.27* | *26.27* | ..... |

*4063—Discrepancy in valuation due to inadequacy of guaranty.

*4188—Chlorin excessive. Discrepancy in valuation due to inadequacy of guaranty.

*4245—Chlorin excessive.

*4189—Discrepancy in valuation due to inadequacy of guaranty.

*4128—Not properly labeled. Negligible quantities of plant foods present.

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Los Angeles Fertilizer Co.—** *Continued.* | | |
| 3743 | Fruit Grower | J. D. McClenny, Pomona | 25.14 |
| 3776 | Fruit Grower | E. F. Wilson, Upland | 27.20 |
| | *Guaranteed* | | *23.20* |
| 3748 | Fruitmore | J. D. McClenny, Pomona | 32.28 |
| 3777 | Fruitmore | E. F. Wilson, Upland | 30.83 |
| | *Guaranteed* | | *30.01* |
| 3746 | Hanson's Odorless Lawn | J. D. McClenny, Pomona | 22.99 |
| 3794 | Hanson's Odorless Lawn | E. F. Wilson, Upland | 24.79 |
| | *Guaranteed* | | *22.22* |
| 3766 | Justright | E. F. Wilson, Upland | 27.26 |
| | *Guaranteed* | | *28.16* |
| 3762* | L. A. Bone Meal | E. F. Wilson, Upland | 38.25 |
| 3818* | L. A. Bone Meal | J. S. Benner, San Bernardino | 37.81 |
| 3833* | L. A. Bone Meal | Covina Citrus Assn., Covina | 36.64 |
| | *Guaranteed* | | *34.40* |
| 3744 | L. A. Garden and Lawn | J. D. McClenny, Pomona | 26.25 |
| | *Guaranteed* | | *24.29* |
| 3763 | Orangeaid | E. F. Wilson, Upland | 31.99 |
| | *Guaranteed* | | *32.36* |
| 3761* | Special | E. F. Wilson, Upland | 41.48 |
| | *Guaranteed* | | *37.62* |
| 3775 | Special Fruit Grower | E. F. Wilson, Upland | 31.25 |
| 3944 | Special Fruit Grower | Jonas & Wright, Rialto | 30.07 |
| 4032 | Special Fruit Grower | H. E. Winslow, Rialto | 30.90 |
| | *Guaranteed* | | *30.32* |
| 3745 | Spring Special | J. D. McClenny, Pomona | 29.68 |
| 3778 | Spring Special | E. F. Wilson, Upland | 31.29 |
| 3945 | Spring Special | Jonas & Wright, Rialto | 30.29 |
| | *Guaranteed* | | *31.60* |
| 3767 | Spring Special | E. F. Wilson, Upland | 31.85 |
| | *Guaranteed* | | *30.60* |
| 3700 | Sulfate of Potash | Windermere Ranch, La Mirada | 57.32 |
| | *Guaranteed* | | *56.41* |
| 3747* | Tankage | J. D. McClenny, Pomona | 29.96 |
| | *Guaranteed* | | *30.40* |
| 3779* | Tankage | E. F. Wilson, Upland | 39.27 |
| | *Guaranteed* | | *37.39* |

*3762—45% fine.
*3818—43% fine.
*3833—42% fine. Some hoof.
*3761—Derivations not guaranteed.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 3743 | 6.47 | 1.88 | 8.35 | ..... | 1.28 | 0.20 | 1.80 | ..... | 3.28 | 3.75 | 3.75 | ..... |
| 3776 | 7.40 | 2.80 | 10.20 | ..... | 1.62 | ..... | 1.89 | ..... | 3.51 | 3.36 | 3.36 | ..... |
| ..... | *6.00* | *2.00* | *8.00* | *Super, Bn, T* | *0.75* | *0.60* | *1.65* | *Bl, Bn, T* | *3.00* | *3.00* | *3.00* | ..... |
| 3748 | 10.17 | 2.48 | 12.65 | ..... | 1.03 | 0.15 | 1.87 | ..... | 3.05 | 6.72 | 6.72 | 0.68 |
| 3777 | 11.80 | 1.80 | 13.60 | ..... | 0.96 | 0.15 | 1.40 | ..... | 2.51 | 6.68 | 6.68 | ..... |
| ..... | *9.00* | *2.50* | *11.50* | *Super, Bn, T* | *0.50* | ..... | *2.00* | *Bl, Bn, T* | *2.50* | *7.00* | *7.00* | ..... |
| 3746 | 7.91 | 0.44 | 8.35 | ..... | 3.96 | ..... | ..... | ..... | 3.96 | 3.85 | 3.85 | ..... |
| 3794 | 8.06 | 0.54 | 8.60 | ..... | 4.48 | ..... | ..... | ..... | 4.48 | 4.03 | 4.03 | ..... |
| ..... | *8.00* | *0.50* | *8.50* | *Super* | *4.00* | ..... | ..... | ..... | *4.00* | *3.00* | *3.00* | ..... |
| 3766 | 8.36 | 1.24 | 9.60 | ..... | 1.10 | ..... | 0.90 | ..... | 2.00 | 9.18 | **9.18** | ..... |
| ..... | *7.00* | *2.00* | *9.00* | *Super, Bn* | *0.50* | *0.50* | *1.00* | *Bl, Bn* | *2.00* | *10.00* | *10.00* | ..... |
| 3762 | ..... | ..... | 23.80 | ..... | ..... | ..... | 3.17 | ..... | 3.17 | ..... | ..... | ..... |
| 3818 | ..... | ..... | 23.00 | ..... | ..... | ..... | 3.25 | ..... | 3.25 | ..... | ..... | ..... |
| 3833 | ..... | ..... | 22.60 | ..... | ..... | ..... | 3.08 | ..... | 3.08 | ..... | ..... | ..... |
| ..... | ..... | ..... | *23.00* | ..... | ..... | ..... | *2.50* | ..... | *2.50* | ..... | ..... | ..... |
| 3744 | 5.61 | 2.24 | 7.85 | ..... | 1.35 | 0.20 | 1.90 | ..... | 3.45 | 4.59 | 4.59 | ..... |
| ..... | *5.00* | *1.00* | *6.00* | *Super, Bn, T* | *1.00* | *0.50* | *2.00* | *Bl, Bn, T* | *3.50* | *4.00* | *4.00* | ..... |
| 3763 | 8.56 | 2.24 | 10.80 | ..... | 1.77 | 0.15 | 1.70 | ..... | **3.62** | 6.94 | 6.94 | ..... |
| ..... | *8.00* | *2.00* | *10.00* | *Super, Bn, G* | *1.00* | *1.00* | *2.00* | *Bl, Bn G, T* | *4.00* | *6.00* | *6.00* | ..... |
| 3761 | ..... | ..... | 13.25 | ..... | ..... | ..... | 5.85 | ..... | 5.85 | ..... | **4.17** | 1.40 |
| ..... | ..... | ..... | *12.00* | ..... | ..... | ..... | ..... | ..... | *5.00* | | *5.00* | ..... |
| 3775 | 8.38 | 3.62 | 12.00 | ..... | 1.70 | 0.20 | 2.00 | ..... | 3.90 | 4.06 | 4.06 | ..... |
| 3944 | 8.63 | 1.72 | 10.35 | ..... | 1.31 | 0.93 | 1.80 | ..... | 4.04 | 3.94 | 3.94 | ..... |
| 4032 | 9.04 | 1.66 | 10.70 | ..... | 1.53 | 1.00 | 1.76 | ..... | 4.29 | 3.77 | 3.77 | ..... |
| ..... | *8.00* | *2.00* | *10.00* | *Super, Bn, T* | *1.00* | *0.75* | *2.25* | *Bl, Bn, T* | *4.00* | *4.00* | *4.00* | ..... |
| 3745 | 9.06 | 1.24 | 10.30 | ..... | 2.67 | ..... | 2.10 | ..... | 4.77 | 2.00 | 2.00 | ..... |
| 3778 | 8.00 | 1.90 | 9.90 | ..... | 3.44 | ..... | 2.04 | ..... | 5.48 | 2.10 | 2.10 | ..... |
| 3945 | 7.58 | 2.62 | 10.20 | ..... | 2.34 | 1.09 | 1.50 | ..... | 4.93 | 2.41 | 2.41 | ..... |
| ..... | *8.00* | *2.00* | *10.00* | *Super, Bn, T* | *2.00* | ..... | *3.00* | *Bl, Bn, T* | *5.00* | *2.00* | *2.00* | ..... |
| 3767 | 8.47 | 1.68 | 10.15 | ..... | 3.00 | ..... | 2.32 | ..... | 5.32 | 2.34 | 2.34 | ..... |
| ..... | *8.00* | *1.00* | *9.00* | *Super, Bn, T* | *2.00* | ..... | *3.00* | *Bl, Bn, T* | *5.00* | *2.00* | *2.00* | ..... |
| 3700 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 50.28 | 50.28 | 1.20 |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | *49.48* | *49.48* | ..... |
| 3747 | ..... | ..... | 11.65 | ..... | ..... | ..... | 4.63 | ..... | **4.63** | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | *Bn* | ..... | ..... | *5.00* | *Bl, Bn* | *5.00* | ..... | ..... | ..... |
| 3779 | ..... | ..... | 15.50 | ..... | ..... | ..... | 6.01 | ..... | 6.01 | ..... | ..... | ..... |
| ..... | ..... | ..... | *15.00* | *Bn* | ..... | ..... | *5.70* | *Bl, Bn* | *5.70* | ..... | ..... | ..... |

*3747—84% fine.

*3779—84% fine.

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Los Angeles Fertilizer Co.—** *Continued.* | | |
| 3853* | Tankage | A. W. Towne, Pomona | 30.06 |
| | *Guaranteed* | | *21.28* |
| 4179* | Tankage | Geo. Adamson, Pomona | 47.91 |
| | *Guaranteed* | | *47.38* |
| 3760 | T. and P. | E. F. Wilson, Upland | 37.01 |
| | *Guaranteed* | | *36.48* |
| 3727 | Three Queens Brand | W. T. Schaffner, Upland | 34.73 |
| | *Guaranteed* | | *35.10* |
| | **Morris & Co., Chicago, Ill.** | | |
| 3787 | Blood | Glendora Citrus Assn., Glendora | **65.53** |
| 3865 | Blood | Glendora Citrus Assn., Glendora | **60.60** |
| | *Guaranteed* | | *66.08* |
| 3939 | Blood | Glendora Citrus Assn., Glendora | ..... |
| | *Sold on Station Analysis.* | | |
| 3831 | Pacific Big 1 | Covina Citrus Assn., Covina | 37.31 |
| | *Guaranteed* | | *36.30* |
| 3810* | Pacific Big 2 | L. E. Loveland, Pomona | 40.42 |
| 3834* | Pacific Big 2 | Covina Citrus Assn., Covina | 38.46 |
| 3862* | Pacific Big 2 | A. A. Cox, San Bernardino | 40.04 |
| 3999* | Pacific Big 2 | Fitzgerald & Barry, Los Angeles | 37.24 |
| 4000* | Pacific Big 2 | Fitzgerald & Barry, Los Angeles | 37.25 |
| | *Guaranteed* | | *39.26* |
| 3788* | Pacific Big 4 | Glendora Citrus Assn., Glendora | 49.08 |
| 3830* | Pacific Big 4 | San Dimas Citrus Nurseries, San Dimas | **46.79** |
| 3884* | Pacific Big 4 | C. C. Chapman, Fullerton | 48.73 |
| 3885* | Pacific Big 4 | C. C. Chapman, Fullerton | 48.91 |
| 3920* | Pacific Big 4 | J. R. McKinley, Rialto | 50.16 |
| 3940* | Pacific Big 4 | Glendora Citrus Assn., Glendora | 49.25 |
| 3961* | Pacific Big 4 | A. W. Richards, Claremont | 48.74 |
| 3992* | Pacific Big 4 | W. A. Nichols, Redlands | 48.92 |
| 4035* | Pacific Big 4 | Rialto Orange Co., Rialto | 47.80 |
| 4051* | Pacific Big 4 | E. L. Decker, Pomona | 49.20 |
| | *Guaranteed* | | *49.23* |
| 4203 | Pacific Big 5 | G. F. North, Los Angeles | 41.33 |
| | *Guaranteed* | | *41.33* |
| 3689* | Pacific Big 6 | C. C. Chapman, Fullerton | 34.19 |
| | *Guaranteed* | | *31.74* |
| 3815 | Pacific Big 8 | R. J. Laidlaw, Placentia | 42.85 |
| | *Guaranteed* | | *40.96* |
| 3851* | Pacific Big 9 | N. F. Morse, Fullerton | 45.33 |

*3853—63% fine. Some hoof.
*4179—67% fine.
*3810—67% fine.
*3834—72% fine.
*3862—67% fine.
*3999—60% fine.
*4000—61% fine.
*3788—75% fine.
*3830—80% fine.
*3884—82% fine.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 3853 | ..... | ..... | 11.00 | ..... | ..... | ..... | 4.76 | ..... | 4.76 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | *Bn* | ..... | ..... | *3.00* | *Bl, Bn* | *3.00* | ..... | ..... | ..... |
| 4179 | ..... | ..... | 7.25 | ..... | ..... | ..... | 9.30 | ..... | 9.30 | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.35* | *Bn* | ..... | ..... | *9.50* | *Bl, Bn* | *9.50* | ..... | ..... | ..... |
| 3760 | ..... | ..... | 12.55 | ..... | ..... | ..... | 4.76 | ..... | 4.76 | 5.07 | 5.07 | 0.95 |
| ..... | ..... | ..... | *12.00* | *Bn* | ..... | ..... | *5.00* | *Bl, Bn* | *5.00* | *4.00* | *4.00* | ..... |
| 3727 | 10.53 | 7.72 | 18.25 | ..... | ..... | ..... | 1.93 | ..... | 1.93 | 6.74 | 6.74 | ..... |
| ..... | ..... | ..... | *18.00* | *Bn* | ..... | ..... | *2.00* | *Bn* | *2.00* | *7.00* | *7.00* | ..... |
| 3787 | ..... | ..... | ..... | ..... | ..... | ..... | 13.46 | ..... | **13.46** | ..... | ..... | ..... |
| 3865 | ..... | ..... | ..... | ..... | ..... | ..... | 12.84 | ..... | **12.84** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *14.00* | ..... | *14.00* | ..... | ..... | ..... |
| 3939 | ..... | ..... | ..... | ..... | ..... | ..... | 13.64 | ..... | 13.64 | ..... | ..... | ..... |
| 3831 | ..... | ..... | 28.20 | ..... | ..... | ..... | 1.06 | ..... | 1.06 | 3.75 | 3.75 | ..... |
| ..... | ..... | ..... | *28.00* | *Bn* | ..... | ..... | *0.82* | *Bn* | *0.82* | *4.00* | *4.00* | ..... |
| 3810 | ..... | ..... | 27.20 | ..... | ..... | ..... | 2.90 | ..... | 2.90 | ..... | ..... | ..... |
| 3834 | ..... | ..... | 28.20 | ..... | ..... | ..... | 2.25 | ..... | 2.25 | ..... | ..... | ..... |
| 3862 | ..... | ..... | 27.60 | ..... | ..... | ..... | 2.73 | ..... | 2.73 | ..... | ..... | ..... |
| 3999 | ..... | ..... | **26.30** | ..... | ..... | ..... | 2.40 | ..... | 2.40 | ..... | ..... | ..... |
| 4000 | ..... | ..... | **25.90** | ..... | ..... | ..... | 2.49 | ..... | 2.49 | ..... | ..... | ..... |
| ..... | ..... | ..... | *28.00* | *Bn* | ..... | ..... | *2.47* | *Bn* | *2.47* | ..... | ..... | ..... |
| 3788 | ..... | ..... | 5.55 | ..... | ..... | ..... | 9.84 | ..... | 9.84 | ..... | ..... | ..... |
| 3830 | ..... | ..... | 6.20 | ..... | ..... | ..... | 9.23 | ..... | **9.23** | ..... | ..... | ..... |
| 3884 | ..... | ..... | 6.30 | ..... | ..... | ..... | 9.64 | ..... | 9.64 | ..... | ..... | ..... |
| 3885 | ..... | ..... | 6.60 | ..... | ..... | ..... | 9.63 | ..... | 9.63 | ..... | ..... | ..... |
| 3920 | ..... | ..... | 6.00 | ..... | ..... | ..... | 10.00 | ..... | 10.00 | ..... | ..... | ..... |
| 3940 | ..... | ..... | 5.30 | ..... | ..... | ..... | 9.92 | ..... | 9.92 | ..... | ..... | ..... |
| 3961 | ..... | ..... | 5.35 | ..... | ..... | ..... | 9.80 | ..... | 9.80 | ..... | ..... | ..... |
| 3992 | ..... | ..... | 5.15 | ..... | ..... | ..... | 9.87 | ..... | 9.87 | ..... | ..... | ..... |
| 4035 | ..... | ..... | 5.00 | ..... | ..... | ..... | 9.65 | ..... | 9.65 | ..... | ..... | ..... |
| 4051 | ..... | ..... | 5.35 | ..... | ..... | ..... | 9.90 | ..... | 9.90 | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.50* | Bn | ..... | ..... | *9.88* | *Bl, Bn* | *9.88* | ..... | ..... | ..... |
| 4203 | ..... | ..... | 4.95 | ..... | ..... | ..... | 8.24 | ..... | 8.24 | 4.35 | 4.35 | ..... |
| ..... | ..... | ..... | *5.00* | *Bn, T* | ..... | ..... | *8.23* | *Bn, T* | *8.23* | *4.00* | *4.00* | ..... |
| 3689 | ..... | ..... | 31.00 | ..... | ..... | ..... | 0.70 | ..... | 0.70 | ..... | ..... | ..... |
| ..... | ..... | ..... | *28.00* | *Bn* | ..... | ..... | *0.82* | *Bn* | *0.82* | ..... | ..... | ..... |
| 3815 | ..... | ..... | 26.30 | ..... | ..... | ..... | 2.51 | ..... | 2.51 | 4.48 | 4.48 | ..... |
| ..... | ..... | ..... | *25.00* | *Bn* | ..... | ..... | *2.50* | *Bn* | *2.50* | *4.00* | *4.00* | ..... |
| 3851 | ..... | ..... | 21.30 | ..... | ..... | ..... | 5.27 | ..... | 5.27 | ..... | ..... | ..... |

*3885—81% fine.
*3920—81% fine.
*3940—83% fine.
*3961—81% fine.
*3992—88% fine.
*4035—80% fine.
*4051—85% fine.
*3689—70% fine.
*3851—63% fine.

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Morris & Co.**—*Continued.* | | |
| 3900* | Pacific Big 9 | F. D. Parker, Hollywood | 39.01 |
| | *Guaranteed* | | *38.91* |
| 4236 | Pacific Big 10 | W. A. Nichols, Redlands | 38.15 |
| 4243 | Pacific Big 10 | Rialto Orange Co., Rialto | 39.22 |
| | *Guaranteed* | | *38.94* |
| 3786 | Pacific Big 11 | Glendora Citrus Assn., Glendora | 32.12 |
| 3832 | Pacific Big 11 | Covina Citrus Assn., Covina | 30.19 |
| | *Guaranteed* | | *31.14* |
| 4037* | Tankage | Azusa Citrus Assn., Azusa | ..... |
| 4049* | Tankage | Azusa Citrus Assn., Azusa | ..... |
| 4050* | Tankage | Azusa Citrus Assn., Azusa | ..... |
| 4053* | Tankage | Azusa Citrus Assn., Azusa | ..... |
| 4180* | Tankage | E. K. Alpaugh, San Gabriel | ..... |
| 4204* | Tankage | Azusa Citrus Assn., Azusa | ..... |
| | *Sold on Station Analysis.* | | |
| | **Mountain Copper Co., San Francisco, Cal.** | | |
| 4108 | *0–3–3* | Grange Conpany, Ceres | 7.45 |
| | *Guaranteed* | | *6.24* |
| 3753 | *2½–10–8* | Redlands Fruit Assn., Redlands | 27.23 |
| | *Guaranteed* | | *27.00* |
| 4121 | *3–10–2* | Valley Seed Co., Sacramento | 24.33 |
| | *Guaranteed* | | *20.90* |
| 4131 | *3–10–5* | J. W. White, Fair Oaks | 25.70 |
| | *Guaranteed* | | *25.30* |
| 3979 | *4–10–4* | Sparr Fruit Co., Los Angeles | 28.74 |
| 4129 | *4–10–4* | J. W. White, Fair Oaks | 27.68 |
| | *Guaranteed* | | *27.61* |
| 4026 | *4.1–10–1½* | Mtn. View O. & L. Assn., Upland | 27.62 |
| 4033 | *4.1–10–1½* | Corona Citrus Assn., Corona | 26.73 |
| 4111 | *4.1–10–1½* | Lindsay Citrus Assn., Lindsay | 27.35 |
| 4142 | *4.1–10–1½* | West Highland Citrus Assn., Highland | 25.72 |
| | *Guaranteed* | | *25.58* |
| 4028 | *7–10½–0* | Arthur Bowring, Charter Oak | 39.23 |
| | *Guaranteed* | | *39.81* |
| 3645 | Superphosphate | Corona Lemon Co., Corona | 17.87 |
| 3768 | Superphosphate | Placentia Fruit Co., Placentia | 17.69 |
| 3803 | Superphosphate | N. W. Blanchard, Santa Paula | 17.81 |
| | *Guaranteed* | | *17.57* |
| 3754 | Superphosphate | Redlands Fruit Assn., Redlands | 18.27 |
| | *Guaranteed* | | *16.45* |
| 3876 | Superphosphate | H. P. Greene, San Diego | 17.32 |

*3900—74% fine.
*4037—83% fine.
*4049—87% fine.
*4050—84% fine.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 3900 | ..... | ..... | 19.50 | ..... | ..... | ..... | 4.28 | ..... | 4.28 | ..... | ..... | ..... |
| ..... | ..... | ..... | *18.30* | *Bn, T* | ..... | ..... | *4.52* | *Bn, T* | *4.52* | ..... | ..... | ..... |
| 4236 | ..... | ..... | 14.80 | ..... | ..... | ..... | 3.80 | ..... | 3.80 | 5.29 | 5.29 | ..... |
| 4243 | ..... | ..... | 14.80 | ..... | ..... | ..... | 3.95 | ..... | 3.95 | 5.63 | 5.63 | ..... |
| ..... | ..... | ..... | *15.00* | *Bn, T* | ..... | ..... | *4.00* | *Bn, T* | *4.00* | *5.00* | *5.00* | ..... |
| 3786 | ..... | ..... | 16.55 | ..... | ..... | ..... | 0.92 | ..... | 0.92 | 9.98 | 9.98 | ..... |
| 3832 | ..... | ..... | 15.85 | ..... | ..... | ..... | 0.86 | ..... | 0.86 | 9.14 | **9.14** | ..... |
| ..... | ..... | ..... | *16.00* | *Bn* | ..... | ..... | *0.82* | *Bn* | *0.82* | *10.00* | *10.00* | ..... |
| 4037 | ..... | ..... | 5.70 | ..... | ..... | ..... | 8.88 | ..... | 8.88 | ..... | ..... | ..... |
| 4049 | ..... | ..... | 6.45 | ..... | ..... | ..... | 9.29 | ..... | 9.29 | ..... | ..... | ..... |
| 4050 | ..... | ..... | 5.37 | ..... | ..... | ..... | 9.44 | ..... | 9.44 | ..... | ..... | ..... |
| 4053 | ..... | ..... | 6.45 | ..... | ..... | ..... | 8.90 | ..... | 8.90 | ..... | ..... | ..... |
| 4180 | ..... | ..... | 6.40 | ..... | ..... | ..... | 9.19 | ..... | 9.19 | ..... | ..... | ..... |
| 4204 | ..... | ..... | 5.65 | ..... | ..... | ..... | 8.98 | ..... | 8.98 | ..... | ..... | ..... |
| 4108 | 4.10 | 0.10 | 4.20 | ..... | ..... | ..... | ..... | ..... | ..... | 3.16 | 3.16 | ..... |
| ..... | *3.00* | *0.50* | *3.50* | *Super* | ..... | ..... | ..... | ..... | ..... | *3.00* | *3.00* | ..... |
| 3753 | 10.26 | 0.44 | 10.70 | ..... | 1.53 | ..... | 0.82 | ..... | 2.35 | 8.37 | 8.37 | ..... |
| ..... | *10.00* | *0.50* | *10.50* | *Super* | *1.67* | ..... | *0.83* | *Bl* | *2.50* | *8.00* | *8.00* | ..... |
| 4121 | 10.54 | 0.46 | 11.00 | ..... | 2.52 | ..... | 0.80 | ..... | 3.32 | 3.92 | 3.92 | 0.60 |
| ..... | *10.00* | *0.50* | *10.50* | *Super* | *2.00* | ..... | *1.00* | *Bl* | *3.00* | *2.00* | *2.00* | ..... |
| 4131 | 10.66 | 0.44 | 11.10 | ..... | 2.29 | ..... | 0.78 | ..... | 3.07 | 4.97 | 4.97 | 0.70 |
| ..... | *10.00* | *0.50* | *10.50* | *Super* | *2.00* | ..... | *1.00* | *Bl, T* | *3.00* | *5.00* | *5.00* | ..... |
| 3979 | 10.28 | 0.42 | 10.70 | ..... | 2.51 | ..... | 1.35 | ..... | 3.86 | 4.03 | 4.03 | ..... |
| 4129 | 9.86 | 0.54 | 10.40 | ..... | 2.62 | ..... | 1.30 | ..... | 3.92 | 4.17 | 4.17 | ..... |
| ..... | *10.00* | *0.50* | *10.50* | *Super* | *2.67* | ..... | *1.33* | *Bl* | *4.00* | *4.00* | *4.00* | ..... |
| 4026 | 9.43 | 1.42 | 10.85 | ..... | 2.71 | 0.78 | 0.94 | ..... | 4.43 | 1.80 | 1.80 | ..... |
| 4033 | 9.39 | 1.36 | 10.75 | ..... | 2.66 | 0.70 | 0.90 | ..... | 4.26 | 1.64 | 1.64 | ..... |
| 4111 | 9.49 | 0.96 | 10.45 | ..... | 3.10 | 0.60 | 0.93 | ..... | 4.63 | 1.55 | 1.55 | ..... |
| 4142 | 9.06 | 1.04 | 10.10 | ..... | 2.47 | 0.65 | 0.95 | ..... | 4.07 | 1.77 | 1.77 | 0.60 |
| ..... | *9.00* | *1.00* | *10.00* | *Super, Bn* | *2.35* | *0.75* | *1.00* | *Bat G Bl, Bn, T* | *4.10* | *1.50* | *1.50* | ..... |
| 4028 | 11.19 | 0.16 | 11.35 | ..... | 2.32 | ..... | 4.68 | ..... | 7.00 | ..... | ..... | ..... |
| ..... | *10.00* | *0.50* | *10.50* | *Super, Bn* | *1.50* | ..... | *5.50* | *Bat G Bl, Bn, T* | *7.00* | ..... | ..... | ..... |
| 3645 | 19.01 | 0.39 | 19.40 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3768 | 18.84 | 0.36 | 19.20 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3803 | 18.96 | 0.34 | 19.30 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *18.70* | *0.30* | *19.00* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3754 | 19.44 | 0.46 | 19.90 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *17.50* | *0.45* | *17.95* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3876 | 18.44 | 0.36 | 18.80 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

*4053—87% fine.
*4180—86% fine.
*4204—89% fine.

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Morris & Co.—*Continued.*** | | |
| 4098 | Superphosphate | Fresno Fuel Co., Fresno | 16.60 |
| | *Guaranteed* | | *16.73* |
| 3978 | Superphosphate | Sparr Fruit Co., Los Angeles | 17.09 |
| | *Guaranteed* | | *16.87* |
| 4159 | Superphosphate | Hammon Orchards, Oroville | 19.98 |
| | *Guaranteed* | | *19.90* |
| 4205 | Superphosphate | H. D. Derwin, Upland | 19.87 |
| | *Guaranteed* | | *20.38* |
| 4206 | Superphosphate | H. D. Derwin, Upland | 19.90 |
| | *Guaranteed* | | *20.05* |
| 4107* | Superphosphate *0–5–0* | Grange Co., Ceres | 5.16 |
| | *Guaranteed* | | *4.70* |
| | **Nitrate Agencies Co., Los Angeles, Cal.** | | |
| 3880* | Bone Meal | F. A. Springstead, El Cajon | 37.92 |
| | *Guaranteed* | | *31.74* |
| 3772 | Nitrate of Soda | Smith & Miner, Santa Ana | 44.29 |
| 3875 | Nitrate of Soda | H. P. Greene, San Diego | 43.62 |
| 3977 | Nitrate of Soda | Sparr Fruit Co., Los Angeles | 43.68 |
| 4116 | Nitrate of Soda | W. L. Benepe, Sebastopol | 44.10 |
| 4126 | Nitrate of Soda | Fair Oaks Fruit Co., Fair Oaks | 43.62 |
| 4153 | Nitrate of Soda | J. F. Fitzgerald, Palermo | 44.92 |
| 4158 | Nitrate of Soda | Hammon Orchards, Oroville | 43.06 |
| | *Guaranteed* | | *42.30* |
| | **Pacific Bone, Coal & Fertilizing Co., San Francisco, Cal.** | | |
| 4084 | Citrona No. 1 | Porterville Citrus Assn., Porterville | 30.41 |
| | *Guaranteed* | | *29.05* |
| 4065 | Citrona No. 2 | W. S. Cairns, Lindsay | 30.78 |
| 4078 | Citrona No. 2 | J. A. Milligan, Porterville | 31.90 |
| 4087 | Citrona No. 2 | C. O. Cowles, Lindsay | 31.76 |
| | *Guaranteed* | | *30.99* |
| 4077 | Citrona No. 3 | Harrison Ranch, Porterville | 32.51 |
| | *Guaranteed* | | *30.97* |
| 4133 | Flora | Penryn Fruit Co., Penryn | 30.16 |
| | *Guaranteed* | | *29.19* |
| 4138 | Lupine | United Fruit Co., New Castle | 20.99 |
| | *Guaranteed* | | *19.86* |
| 4104 | Merino | Fancher Creek Nurseries, Fresno | 21.73 |
| | *Guaranteed* | | *21.91* |

4107—Values stated do not include allowance for gypsum.

*3880—96% fine.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 4098 | 17.66 | 0.24 | 17.90 | | | | | | | | | |
| | *17.80* | *0.55* | *18.35* | | | | | | | | | |
| 3978 | 18.18 | 0.52 | 18.70 | | | | | | | | | |
| | *17.95* | *0.50* | *18.45* | | | | | | | | | |
| 4159 | 21.26 | 0.24 | 21.50 | | | | | | | | | |
| | *21.17* | *0.27* | *21.44* | | | | | | | | | |
| 4205 | 21.14 | 0.26 | 21.40 | | | | | | | | | |
| | *21.68* | *0.26* | *21.94* | | | | | | | | | |
| 4206 | 21.18 | 0.22 | 21.40 | | | | | | | | | |
| | *21.33* | *0.26* | *21.59* | | | | | | | | | |
| 4107 | 5.49 | 0.36 | 5.85 | | | | | | | | | |
| | *5.00* | *0.20* | *5.20* | | | | | | | | | |
| 3880 | | | 33.50 | | | | 0.97 | | 0.97 | | | |
| | | | *28.00* | | | | *0.82* | | *0.82* | | | |
| 3772 | | | | | 15.71 | | | | 15.71 | | | |
| 3875 | | | | | 15.47 | | | | 15.47 | | | |
| 3977 | | | | | 15.49 | | | | 15.49 | | | |
| 4116 | | | | | 15.64 | | | | 15.64 | | | |
| 4126 | | | | | 15.47 | | | | 15.47 | | | |
| 4153 | | | | | 15.93 | | | | 15.93 | | | |
| 4158 | | | | | 15.27 | | | | 15.27 | | | |
| | | | | | *15.00* | | | | *15.00* | | | |
| 4084 | 7.64 | 3.16 | 10.80 | | 1.67 | | 1.35 | | 3.02 | 7.67 | 7.67 | 0.90 |
| | *7.00* | *3.00* | *10.00* | *Super, Bn* | *1.50* | | *1.50* | *Bl, Bn, T* | *3.00* | *7.00* | *7.00* | |
| 4065 | 7.96 | 1.54 | 9.50 | | 2.44 | | 1.39 | | 3.83 | 7.08 | 7.08 | 0.90 |
| 4078 | 6.76 | 2.54 | 9.30 | | 2.77 | | 1.38 | | 4.15 | 7.46 | 7.46 | 1.00 |
| 4087 | 7.26 | 2.64 | 9.90 | | 2.43 | | 1.38 | | 3.81 | 7.65 | 7.65 | 1.00 |
| | *6.00* | *3.00* | *9.00* | *Super, Bn* | *2.43* | | *1.57* | *Bl, Bn, T* | *4.00* | *7.00* | *7.00* | |
| 4077 | 6.70 | 3.20 | 9.90 | | 1.62 | | 1.31 | | 2.93 | 10.60 | 10.60 | 1.15 |
| | *5.50* | *3.00* | *8.50* | *Super, Bn* | *1.50* | | *1.50* | *Bl, Bn, T* | *3.00* | *10.00* | *10.00* | |
| 4133 | 7.55 | 2.30 | 9.85 | | 1.86 | | 1.66 | | 3.52 | 6.58 | 6.58 | 0.90 |
| | *6.00* | *3.00* | *9.00* | *Super, Bn* | *1.50* | | *2.00* | *Bl, Bn, T* | *3.50* | *6.00* | *6.00* | |
| 4138 | 10.34 | 0.56 | 10.90 | | | | | | | 9.90 | 9.90 | 0.90 |
| | *9.00* | *1.00* | *10.00* | *Super* | | | | | | *10.00* | *10.00* | |
| 4104 | 4.76 | 1.44 | 6.20 | | 1.77 | | 1.03 | | 2.80 | | 5.12 | 1.50 |
| | *2.00* | *3.50* | *5.50* | *Super* | *1.70* | | *1.30* | *Bn, SM* | *3.00* | *5.00* | *5.00* | |

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Morris & Co.—*Continued.*** | | |
| 4098 | Superphosphate | Fresno Fuel Co., Fresno | 16.60 |
| | *Guaranteed* | | *16.73* |
| 3978 | Superphosphate | Sparr Fruit Co., Los Angeles | 17.09 |
| | *Guaranteed* | | *16.87* |
| 4159 | Superphosphate | Hammon Orchards, Oroville | 19.98 |
| | *Guaranteed* | | *19.90* |
| 4205 | Superphosphate | H. D. Derwin, Upland | 19.87 |
| | *Guaranteed* | | *20.38* |
| 4206 | Superphosphate | H. D. Derwin, Upland | 19.90 |
| | *Guaranteed* | | *20.05* |
| 4107* | Superphosphate *0–5–0* | Grange Co., Ceres | 5.16 |
| | *Guaranteed* | | *4.70* |
| | **Nitrate Agencies Co., Los Angeles, Cal.** | | |
| 3880* | Bone Meal | F. A. Springstead, El Cajon | 37.92 |
| | *Guaranteed* | | *31.74* |
| 3772 | Nitrate of Soda | Smith & Miner, Santa Ana | 44.29 |
| 3875 | Nitrate of Soda | H. P. Greene, San Diego | 43.62 |
| 3977 | Nitrate of Soda | Sparr Fruit Co., Los Angeles | 43.68 |
| 4116 | Nitrate of Soda | W. L. Benepe, Sebastopol | 44.10 |
| 4126 | Nitrate of Soda | Fair Oaks Fruit Co., Fair Oaks | 43.62 |
| 4153 | Nitrate of Soda | J. F. Fitzgerald, Palermo | 44.92 |
| 4158 | Nitrate of Soda | Hammon Orchards, Oroville | 43.06 |
| | *Guaranteed* | | *42.30* |
| | **Pacific Bone, Coal & Fertilizing Co., San Francisco, Cal.** | | |
| 4084 | Citrona No. 1 | Porterville Citrus Assn., Porterville | 30.41 |
| | *Guaranteed* | | *29.05* |
| 4065 | Citrona No. 2 | W. S. Cairns, Lindsay | 30.78 |
| 4078 | Citrona No. 2 | J. A. Milligan, Porterville | 31.90 |
| 4087 | Citrona No. 2 | C. O. Cowles, Lindsay | 31.76 |
| | *Guaranteed* | | *30.99* |
| 4077 | Citrona No. 3 | Harrison Ranch, Porterville | 32.51 |
| | *Guaranteed* | | *30.97* |
| 4133 | Flora | Penryn Fruit Co., Penryn | 30.16 |
| | *Guaranteed* | | *29.19* |
| 4138 | Lupine | United Fruit Co., New Castle | 20.99 |
| | *Guaranteed* | | *19.86* |
| 4104 | Merino | Fancher Creek Nurseries, Fresno | 21.73 |
| | *Guaranteed* | | *21.91* |

4107—Values stated do not include allowance for gypsum.

*3880—96% fine.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 4098 | 17.66 | 0.24 | 17.90 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *17.80* | *0.55* | *18.35* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3978 | 18.18 | 0.52 | 18.70 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *17.95* | *0.50* | *18.45* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4159 | 21.26 | 0.24 | 21.50 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *21.17* | *0.27* | *21.44* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4205 | 21.14 | 0.26 | 21.40 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *21.68* | *0.26* | *21.94* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4206 | 21.18 | 0.22 | 21.40 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *21.33* | *0.26* | *21.59* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4107 | 5.49 | 0.36 | 5.85 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *5.00* | *0.20* | *5.20* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3880 | ..... | ..... | 33.50 | ..... | ..... | ..... | 0.97 | ..... | 0.97 | ..... | ..... | ..... |
| ..... | ..... | ..... | *28.00* | ..... | ..... | ..... | *0.82* | ..... | *0.82* | ..... | ..... | ..... |
| 3772 | ..... | ..... | ..... | ..... | 15.71 | ..... | ..... | ..... | 15.71 | ..... | ..... | ..... |
| 3875 | ..... | ..... | ..... | ..... | 15.47 | ..... | ..... | ..... | 15.47 | ..... | ..... | ..... |
| 3977 | ..... | ..... | ..... | ..... | 15.49 | ..... | ..... | ..... | 15.49 | ..... | ..... | ..... |
| 4116 | ..... | ..... | ..... | ..... | 15.64 | ..... | ..... | ..... | 15.64 | ..... | ..... | ..... |
| 4126 | ..... | ..... | ..... | ..... | 15.47 | ..... | ..... | ..... | 15.47 | ..... | ..... | ..... |
| 4153 | ..... | ..... | ..... | ..... | 15.93 | ..... | ..... | ..... | 15.93 | ..... | ..... | ..... |
| 4158 | ..... | ..... | ..... | ..... | 15.27 | ..... | ..... | ..... | 15.27 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... |
| 4084 | 7.64 | 3.16 | 10.80 | ..... | 1.67 | ..... | 1.35 | ..... | 3.02 | 7.67 | 7.67 | 0.90 |
| ..... | *7.00* | *3.00* | *10.00* | *Super, Bn* | *1.50* | ..... | *1.50* | *Bl, Bn, T* | *3.00* | *7.00* | *7.00* | ..... |
| 4065 | 7.96 | 1.54 | 9.50 | ..... | 2.44 | ..... | 1.39 | ..... | 3.83 | 7.08 | 7.08 | 0.90 |
| 4078 | 6.76 | 2.54 | 9.30 | ..... | 2.77 | ..... | 1.38 | ..... | 4.15 | 7.46 | 7.46 | 1.00 |
| 4087 | 7.26 | 2.64 | 9.90 | ..... | 2.43 | ..... | 1.38 | ..... | 3.81 | 7.65 | 7.65 | 1.00 |
| ..... | *6.00* | *3.00* | *9.00* | *Super, Bn* | *2.43* | ..... | *1.57* | *Bl, Bn, T* | *4.00* | *7.00* | *7.00* | ..... |
| 4077 | 6.70 | 3.20 | 9.90 | ..... | 1.62 | ..... | 1.31 | ..... | 2.93 | 10.60 | 10.60 | 1.15 |
| ..... | *5.50* | *3.00* | *8.50* | *Super, Bn* | *1.50* | ..... | *1.50* | *Bl, Bn, T* | *3.00* | *10.00* | *10.00* | ..... |
| 4133 | 7.55 | 2.30 | 9.85 | ..... | 1.86 | ..... | 1.66 | ..... | 3.52 | 6.58 | 6.58 | 0.90 |
| ..... | *6.00* | *3.00* | *9.00* | *Super, Bn* | *1.50* | ..... | *2.00* | *Bl, Bn, T* | *3.50* | *6.00* | *6.00* | ..... |
| 4138 | 10.34 | 0.56 | 10.90 | ..... | ..... | ..... | ..... | ..... | ..... | 9.90 | 9.90 | 0.90 |
| | *9.00* | *1.00* | *10.00* | *Super* | ..... | ..... | ..... | ..... | ..... | *10.00* | *10.00* | ..... |
| 4104 | 4.76 | 1.44 | 6.20 | ..... | 1.77 | ..... | 1.03 | ..... | 2.80 | ..... | 5.12 | 1.50 |
| ..... | *2.00* | *3.50* | *5.50* | *Super* | *1.70* | ..... | *1.30* | *Bn, SM* | *3.00* | *5.00* | *5.00* | ..... |

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Pacific Bone, Coal, and Fertilizing Co.**—*Continued.* | | |
| 4059 | Nitrate of Soda | L. E. Orton, Lindsay | 42.88 |
| 4079 | Nitrate of Soda | F. B. Myrick, Porterville | 43.44 |
| 4091 | Nitrate of Soda | T. J. Dofflemyer & Sons, Exeter | 42.66 |
| | *Guaranteed* | | *42.30* |
| 4083 | Nursery Special | Porterville Citrus Assn., Porterville | 33.35 |
| 4094 | Nursery Special | Kaweah Lemon Co., Lemon Cove | 31.72 |
| 4137 | Nursery Special | United Fruit Co., Newcastle | 32.34 |
| | *Guaranteed* | | *31.30* |
| 4086 | Olive Special | Fancher Creek Nurseries, Fresno | 31.85 |
| | *Guaranteed* | | *30.97* |
| 4130 | Pomona | H. E. Butler, Penryn | 30.75 |
| | *Guaranteed* | | *29.33* |
| 4073 | Special No. 312 | A. L. Lewis, Lindsay | 24.46 |
| | *Guaranteed* | | *22.99* |
| 4027 | Spier's Special | L. P. Spiers, San Jose | 32.71 |
| | *Guaranteed* | | *32.61* |
| 4060 | Sulfate of Potash | L. E. Orton, Lindsay | 55.67 |
| 4082 | Sulfate of Potash | J. F. Canty, Porterville | 55.63 |
| 4093 | Sulfate of Potash | T. J. Dofflemyer & Sons, Exeter | 55.58 |
| | *Guaranteed* | | *54.72* |
| 4081 | Superphosphate | J. F. Canty, Porterville | 16.45 |
| 4092 | Superphosphate | T. J. Dofflemyer & Sons, Exeter | 16.30 |
| | *Guaranteed* | | *15.98* |
| | **Pacific Guano & Fertilizer Co., San Francisco, Cal.** | | |
| 4120 | Basic No. 2 | Dickinson-Nelson & Co., Stockton | **8.42** |
| | *Guaranteed* | | *9.40* |
| 4152* | Basic Superphosphate | D. McLean, Palermo | 16.04 |
| | *Guaranteed* | | *8.46* |
| 4052 | Bat Guano | Azusa Citrus Assn., Azusa | ..... |
| | *Sold on Station Analysis.* | | |
| 3709 | Blood | B. L. Byer, Upland | 64.80 |
| | *Guaranteed* | | *64.90* |
| 3943 | Blood | Sellers & Schofield, Glendora | 66.60 |
| | *Guaranteed* | | *66.36* |
| 3736* | Bone Meal | B. L. Byer, Upland | 41.16 |
| | *Guaranteed* | | *40.24* |
| 3942* | Bone Meal | Sellers & Schofield, Glendora | 40.24 |
| | *Guaranteed* | | *39.32* |

*4152—A true superphosphate. Tagged "Basic" in error.

*3736—48% fine.

*3942—56% fine.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 4059 | ..... | ..... | ..... | ..... | 15.21 | ..... | ..... | ..... | 15.21 | ..... | ..... | ..... |
| 4079 | ..... | ..... | ..... | ..... | 15.41 | ..... | ..... | ..... | 15.41 | ..... | ..... | ..... |
| 4091 | ..... | ..... | ..... | ..... | **15.13** | ..... | ..... | ..... | 15.13 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... |
| 4083 | 8.40 | 2.30 | 10.70 | ..... | 2.85 | 0.20 | 1.67 | ..... | 4.72 | ..... | 5.50 | 1.40 |
| 4094 | 8.06 | 2.24 | 10.30 | ..... | 2.76 | ..... | 1.92 | ..... | 4.68 | 4.28 | 4.28 | 0.80 |
| 4137 | 6.67 | 3.08 | 9.75 | ..... | 2.48 | ..... | 1.60 | ..... | **4.08** | 8.30 | 8.30 | 1.00 |
| ..... | *7.00* | *3.00* | *10.00* | *Super, Bn* | *2.43* | ..... | *2.17* | *Bl Bn, T* | *4.60* | *4.00* | *4.00* | ..... |
| 4086 | 6.84 | 2.76 | 9.60 | ..... | 2.02 | ..... | 1.16 | ..... | 3.18 | 9.87 | 9.87 | 0.60 |
| ..... | *5.50* | *3.00* | *8.50* | *Super, Bn* | *1.50* | ..... | *1.50* | *Bl, Bn, T* | *3.00* | *10.00* | *10.00* | ..... |
| 4130 | 7.16 | 2.54 | 9.70 | ..... | 1.57 | ..... | 1.08 | ..... | 2.65 | 10.26 | 10.26 | 0.90 |
| ..... | *6.00* | *2.00* | *8.00* | *Super, Bn* | *1.50* | ..... | *1.25* | *Bl, Bn, T* | *2.75* | *10.00* | *10.00* | ..... |
| 4073 | 9.34 | 1.56 | 10.90 | ..... | 1.32 | ..... | 0.80 | ..... | 2.12 | 8.32 | 8.32 | 0.90 |
| ..... | *7.50* | *2.00* | *9.50* | *Super, Bn* | *1.22* | ..... | *0.78* | *Bl, Bn, T* | *2.00* | *8.50* | *8.50* | ..... |
| 4027 | 7.10 | 2.75 | 9.85 | ..... | 1.66 | ..... | 2.37 | ..... | 4.03 | 6.47 | **6.47** | 1.00 |
| ..... | *6.00* | *3.00* | *9.00* | *Super, Bn* | *1.50* | ..... | *2.50* | *Bl, Bn, T* | *4.00* | *7.00* | *7.00* | ..... |
| 4060 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 48.84 | 48.84 | 2.20 |
| 4082 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 48.80 | 48.80 | 2.00 |
| 4093 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 48.76 | 48.76 | 2.30 |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | *48.00* | *48.00* | ..... |
| 4081 | 17.50 | 0.30 | 17.80 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4092 | 17.34 | 0.46 | 17.80 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *17.00* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4120 | 8.96 | 6.04 | 15.00 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *10.00* | *2.00* | *12.00* | *Min. Phos.* | | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4152 | 17.06 | 0.34 | 17.40 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *9.00* | *3.00* | *12.00* | *Min. Phos.* | | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4052 | ..... | ..... | 2.40 | ..... | 1.24 | 1.00 | 9.03 | ..... | 11.27 | ..... | 1.28 | ..... |
| 3709 | ..... | ..... | ..... | ..... | ..... | ..... | 13.73 | ..... | 13.73 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.75* | ..... | *13.75* | ..... | ..... | ..... |
| 3943 | ..... | ..... | ..... | ..... | ..... | ..... | 14.11 | ..... | 14.11 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *14.06* | ..... | *14.06* | ..... | ..... | ..... |
| 3736 | ..... | ..... | 21.65 | ..... | ..... | ..... | 4.28 | ..... | 4.28 | ..... | ..... | ..... |
| ..... | ..... | ..... | *22.00* | ..... | ..... | ..... | *4.00* | ..... | *4.00* | ..... | ..... | ..... |
| 3942 | ..... | ..... | 22.10 | ..... | ..... | ..... | 3.98 | ..... | 3.98 | ..... | ..... | ..... |
| ..... | ..... | ..... | *22.00* | ..... | ..... | ..... | *3.80* | ..... | *3.80* | ..... | ..... | ..... |

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Pacific Guano & Fertilizer Co.** —*Continued.* | | |
| 3795* | Bone Meal | W. M. Warren, Covina | 37.55 |
| 3863* | Bone Meal | Chas. Silent, Los Angeles | 38.34 |
| | *Guaranteed* | | *36.43* |
| 3724* | Bone Meal | B. S. Casey, Rialto | 42.96 |
| 3809* | Bone Meal | M. S. Ratliff, Colton | 40.05 |
| 4134* | Bone Meal | Pioneer Fruit Co., Newcastle | 41.56 |
| 4239* | Bone Meal | Etiwanda Citrus Assn., Etiwanda | 43.40 |
| | *Guaranteed* | | *39.78* |
| 3836 | Bone, Super. and Potash | W. M. Warren, Covina | 37.84 |
| | *Guaranteed* | | *36.81* |
| 3898 | Diamond F | G. W. Hume Co., Los Gatos | 29.45 |
| 3949 | Diamond F | Sellers & Schofield, Glendora | 30.94 |
| | *Guaranteed* | | *29.01* |
| 3737 | Diamond N | B. L. Byer, Upland | 29.52 |
| 3951 | Diamond N | Sellers & Sclofield, Glendora | 28.55 |
| | *Guaranteed* | | *27.78* |
| 3735 | Diamond S | B. L. Byer, Upland | 37.61 |
| 3952 | Diamond S | Sellers & Scofield, Glendora | 36.87 |
| | *Guaranteed* | | *35.16* |
| 3710* | Diamond T | B. L. Byer, Upland | 29.69 |
| | *Guaranteed* | | *28.46* |
| 3835 | F | W. M. Warren, Covina | 29.54 |
| 4100 | F | Aubrey Frink, Fresno | 28.29 |
| 4124 | F | Fair Oaks Fruit Co., Fair Oaks | 28.55 |
| | *Guaranteed* | | *29.01* |
| 4132 | H | Pioneer Fruit Co., Newcastle | 30.21 |
| | *Guaranteed* | | *30.90* |
| 3734 | Lawn Dressing | B. L. Byer, Upland | 30.11 |
| 3953 | Lawn Dressing | Sellers & Scofield, Glendora | 28.55 |
| 3960 | Lawn Dressing | H. C. Rumohr, Redlands | 30.60 |
| 4119 | Lawn Dressing | Dickinson, Nelson & Co., Stockton | 28.86 |
| | *Guaranteed* | | *27.54* |
| 3957 | Mills Special | H. C. Rumohr, Redlands | 40.98 |
| | *Guaranteed* | | *41.16* |
| 4101 | N | Aubrey Frink, Fresno | 31.16 |
| 4136 | N | Pioneer Fruit Co., Newcastle | 26.52 |

*3795—63% fine.
*3863—63% fine.
*3724—51% fine.
*3809—48% fine.
*4134—38% fine.
4239—54% fine.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 3795 | ..... | ..... | 28.80 | ..... | ..... | ..... | 1.92 | ..... | 1.92 | ..... | ..... | ..... |
| 3863 | ..... | ..... | 29.00 | ..... | ..... | ..... | 2.05 | ..... | 2.05 | ..... | ..... | ..... |
| ..... | ..... | ..... | *27.50* | ..... | ..... | ..... | *1.96* | ..... | *1.96* | ..... | ..... | ..... |
| 3724 | ..... | ..... | 24.40 | ..... | ..... | ..... | 4.07 | ..... | 4.07 | ..... | ..... | ..... |
| 3809 | ..... | ..... | 21.90 | ..... | ..... | ..... | 3.98 | ..... | 3.98 | ..... | ..... | ..... |
| 4134 | ..... | ..... | 23.50 | ..... | ..... | ..... | 3.96 | ..... | 3.96 | ..... | ..... | ..... |
| 4239 | ..... | ..... | 23.80 | ..... | ..... | ..... | 4.30 | ..... | 4.30 | ..... | ..... | ..... |
| ..... | ..... | ..... | *22.00* | ..... | ..... | ..... | *3.90* | ..... | *3.90* | ..... | ..... | ..... |
| 3836 | 10.02 | 7.58 | 17.60 | ..... | ..... | ..... | 2.73 | ..... | 2.73 | 6.85 | 6.85 | ..... |
| ..... | ..... | ..... | *18.00* | *Super, Bn* | ..... | ..... | *2.50* | *Bl, Bn, T* | *2.50* | *6.50* | *6.50* | ..... |
| 3898 | 7.76 | 2.54 | 10.30 | ..... | 0.77 | 0.15 | 1.60 | ..... | 2.52 | 8.02 | 8.02 | 0.80 |
| 3949 | 7.62 | 2.88 | 10.50 | ..... | 0.74 | ..... | 2.33 | ..... | 3.07 | 6.79 | 6.79 | ..... |
| ..... | *8.00* | *2.50* | *10.50* | *Super, Bn* | *0.50* | ..... | *2.00* | *Bl, Bn, Fs G, T* | *2.50* | *7.00* | *7.00* | ..... |
| 3737 | 8.12 | 2.48 | 10.60 | ..... | 1.25 | 0.15 | 2.70 | ..... | 4.10 | 2.24 | 2.24 | ..... |
| 3951 | 7.05 | 2.10 | 9.15 | ..... | 1.31 | 0.15 | 2.75 | ..... | 4.21 | ..... | 2.29 | 1.80 |
| ..... | *8.00* | *1.00* | *9.00* | *Super, Bn* | *1.00* | ..... | *3.00* | *Bl, Bn, Fs* | *4.00* | *2.00* | *2.00* | ..... |
| 3735 | 8.65 | 1.35 | 10.00 | ..... | 2.59 | ..... | 3.90 | ..... | 6.49 | 2.22 | 2.22 | ..... |
| 3952 | 7.85 | 1.30 | 9.15 | ..... | 2.33 | ..... | 4.17 | ..... | 6.50 | 1.88 | 1.88 | ..... |
| ..... | *8.00* | *1.00* | *9.00* | *Super, Bn, G* | *2.00* | ..... | *4.00* | *Bl, Bn, Fs G, T* | *6.00* | *2.00* | *2.00* | ..... |
| 3710 | 6.20 | 1.90 | 8.10 | ..... | 1.96 | ..... | 2.38 | ..... | 4.34 | ..... | 4.57 | ..... |
| ..... | *7.00* | *1.00* | *8.00* | *Super, Bn* | *2.00* | ..... | *2.00* | *Bl, Bn, Fs* | *4.00* | ..... | *5.00* | ..... |
| 3835 | 7.34 | 3.26 | 10.60 | ..... | 0.64 | ..... | 1.76 | ..... | 2.40 | 8.00 | 8.00 | 0.80 |
| 4100 | 8.56 | 2.74 | 11.30 | ..... | 0.88 | ..... | 1.55 | ..... | 2.43 | 6.53 | 6.53 | 0.80 |
| 4124 | 9.10 | 1.00 | 10.10 | ..... | 0.95 | ..... | 1.83 | ..... | 2.78 | 6.52 | 6.52 | 0.90 |
| ..... | *8.00* | *2.50* | *10.50* | *Super, Bn, G* | *0.50* | ..... | *2.00* | *Bl, Bn, Fs, G, T* | *2.50* | *7.00* | *7.00* | ..... |
| 4132 | 8.65 | 2.60 | 11.25 | ..... | 0.77 | ..... | 1.81 | ..... | 2.58 | 7.49 | **7.49** | 1.05 |
| ..... | *7.50* | *2.61* | *10.11* | *Super, Bn* | *0.50* | ..... | *2.00* | *Bl, Bn, Fs, G, T* | *2.50* | *9.00* | *9.00* | ..... |
| 3734 | 10.00 | 0.10 | 10.10 | ..... | ..... | 4.17 | ..... | ..... | 4.17 | 5.08 | 5.08 | ..... |
| 3953 | 10.64 | 1.16 | 11.80 | ..... | 0.17 | 2.93 | 0.72 | ..... | 3.82 | 3.78 | **3.78** | ..... |
| 3960 | 10.10 | 0.10 | 10.20 | ..... | ..... | 4.30 | ..... | ..... | 4.30 | 5.02 | 5.02 | ..... |
| 4119 | 9.12 | 0.48 | 9.60 | ..... | ..... | 4.10 | ..... | ..... | 4.10 | 4.93 | 4.93 | ..... |
| ..... | *8.00* | *1.00* | *9.00* | *Super.* | ..... | *4.00* | ..... | ..... | *4.00* | *5.00* | *5.00* | ..... |
| 3957 | ..... | ..... | 14.90 | ..... | ..... | ..... | 3.84 | ..... | 3.84 | 8.56 | 8.56 | ..... |
| ..... | ..... | ..... | *15.00* | *Bn* | ..... | ..... | *4.00* | *Bl, Bn* | *4.00* | *8.00* | *8.00* | ..... |
| 4101 | **6.85** | 2.70 | 9.55 | ..... | 1.02 | ..... | 3.39 | ..... | 4.41 | 2.88 | 2.88 | ..... |
| 4136 | 7.11 | 1.24 | 8.35 | ..... | 1.43 | ..... | 2.35 | ..... | 3.78 | 3.00 | 3.00 | 0.90 |

*3710—Potash guaranteed, 1% muriate, 4% from sulfate.

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Pacific Guano and Fertilizer Co.**—*Continued.* | | |
| 4144 | N | B. B. Meek, Oroville | 28.91 |
| | *Guaranteed* | | *27.78* |
| 3707 | Nitrate of Soda | B. L. Byer, Upland | 44.39 |
| | *Guaranteed* | | *43.15* |
| 3802 | Nitrate of Soda | N. W. Blanchard, Santa Paula | 44.66 |
| | *Guaranteed* | | *42.30* |
| 4151 | Nitrate of Soda | D. McLean, Palermo | 43.62 |
| | *Guaranteed* | | *42.01* |
| 3708* | P. N. K. | B. L. Byer, Upland | 27.90 |
| 3950 | P. N. K. | Sellers & Sclofield, Glendora | 27.45 |
| | *Guaranteed* | | *25.96* |
| 4102 | P. P. | Aubrey Frink, Fresno | 20.85 |
| 4123 | P. P. | Fair Oaks Fruit Co., Fair Oaks | 20.59 |
| 4135 | P. P. | Pioneer Fruit Co., Newcastle | 22.84 |
| | *Guaranteed* | | *21.54* |
| 4145 | S | B. B. Meek, Oroville | 35.27 |
| | *Guaranteed* | | *35.16* |
| 3807 | Special | Chas. C. Fisher, Rialto | 37.04 |
| | *Guaranteed* | | *36.24* |
| 4040 | Special | Irwindale Citrus Assn., Irwindale | 46.40 |
| | *Guaranteed* | | *45.03* |
| 4041 | Special | G. J. Reynolds, Covina | 43.15 |
| | *Guaranteed* | | *43.09* |
| 4125 | Special | Fair Oaks Fruit Co., Fair Oaks | 33.75 |
| | *Guaranteed* | | *34.16* |
| 4150 | Special N | G. C. Post, Palermo | 26.80 |
| | *Guaranteed* | | *24.30* |
| 3948* | Special Nitrate | Sellers & Scofield, Glendora | 42.66 |
| | *Guaranteed* | | *41.93* |
| 3691 | Sulfate of Potash | C. C. Chapman, Fullerton | **49.84** |
| | *Guaranteed* | | *56.69* |
| 3723 | Sulphate of Potash | O. & L. Grs. Assn., Glendora | 56.13 |
| | *Guaranteed* | | *56.38* |
| 3725 | Sulfate of Potash | B. S. Casey, Rialto | 56.81 |
| | *Guaranteed* | | *56.65* |
| 3738 | Sulfate of Potash | B. L. Byer, Upland | **51.20** |
| | *Guaranteed* | | *56.68* |

*3708—Chlorin excessive.

*3948—This nitrate contains a small amount of bone meal.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 4144 | 8.04 | 1.16 | 9.20 | ..... | 1.16 | ..... | 2.94 | ..... | 4.10 | 2.66 | 2.66 | ..... |
| ..... | *8.00* | *1.00* | *9.00* | *Super, Bn* | *1.00* | ..... | *3.00* | *Bl, Bn, Fs* | *4.00* | *2.00* | *2.00* | ..... |
| 3707 | ..... | ..... | ..... | ..... | 15.74 | ..... | ..... | ..... | 15.74 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.30* | ..... | ..... | ..... | *15.30* | ..... | ..... | ..... |
| 3802 | ..... | ..... | ..... | ..... | 15.84 | ..... | ..... | ..... | 15.84 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... |
| 4151 | ..... | ..... | ..... | ..... | 15.47 | ..... | ..... | ..... | 15.47 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *14.90* | ..... | ..... | ..... | *14.90* | ..... | ..... | ..... |
| 3708 | 8.66 | 2.44 | 11.10 | ..... | ..... | ..... | 2.16 | ..... | 2.16 | ..... | 6.10 | 3.50 |
| 3950 | 6.84 | 3.36 | 10.20 | ..... | ..... | ..... | 2.30 | ..... | 2.30 | 5.94 | 5.94 | ..... |
| ..... | *7.50* | *2.50* | *10.00* | *Super, Bn, G* | ..... | ..... | *2.00* | *Bl, Bn, Fs, G, T* | *2.00* | *6.00* | *6.00* | ..... |
| 4102 | 12.38 | 1.92 | 14.30 | ..... | ..... | ..... | ..... | ..... | ..... | 8.09 | **8.09** | ..... |
| 4123 | 12.50 | 0.50 | 13.00 | ..... | ..... | ..... | ..... | ..... | ..... | 7.76 | **7.76** | ..... |
| 4135 | 12.92 | 0.28 | 13.20 | ..... | ..... | ..... | ..... | ..... | ..... | 9.39 | 9.39 | 0.60 |
| ..... | *12.00* | *1.00* | *13.00* | *Super,* | ..... | ..... | ..... | ..... | ..... | *9.00* | *9.00* | ..... |
| 4145 | 8.02 | 1.48 | 9.50 | ..... | 2.21 | 0.15 | 3.50 | ..... | 5.86 | 2.67 | 2.67 | 0.95 |
| ..... | *8.00* | *1.00* | *9.00* | *Super, Bn, G* | *2.00* | ..... | *4.00* | *Bl, Bn, Fs G, T* | *6.00* | *2.00* | *2.00* | ..... |
| 3807 | 12.65 | 5.05 | 17.70 | ..... | ..... | ..... | 1.17 | ..... | 1.17 | 12.29 | 12.29 | 0.95 |
| ..... | ..... | ..... | *18.00* | *Super, Bn* | ..... | ..... | *1.00* | *Bn* | *1.00* | *12.00* | *12.00* | ..... |
| 4040 | 5.74 | 4.56 | 10.30 | ..... | 1.38 | 0.25 | 6.87 | ..... | 8.50 | ..... | ..... | ..... |
| ..... | *3.46* | *6.21* | *9.67* | *Super, Bn, T* | *1.50* | ..... | *6.83* | *Bl, Bn, T* | *8.33* | ..... | ..... | ..... |
| 4041 | 4.32 | 6.08 | 10.40 | ..... | 1.40 | ..... | 6.32 | ..... | 7.72 | ..... | ..... | ..... |
| ..... | *3.46* | *8.04* | *11.50* | *Super, Bn, T* | *1.50* | ..... | *6.00* | *Bl, Bn, T* | *7.50* | ..... | ..... | ..... |
| 4125 | 7.49 | 0.96 | 8.45 | ..... | 2.44 | ..... | 1.75 | ..... | 4.19 | 9.16 | **9.16** | 1.10 |
| ..... | *7.00* | *1.00* | *8.00* | *Super, Bn* | *2.00* | ..... | *2.00* | *Bl, Bn, T* | *4.00* | *10.00* | *10.00* | ..... |
| 4150 | 8.74 | 0.76 | 9.50 | ..... | 3.28 | ..... | 1.22 | ..... | 4.50 | 2.19 | 2.19 | ..... |
| ..... | *8.00* | *1.00* | *9.00* | *Super, Bn* | *3.00* | ..... | *1.00* | *Bl, Bn, Fs* | *4.00* | *2.00* | *2.00* | ..... |
| 3948 | ..... | ..... | 0.89 | ..... | 15.13 | ..... | 0.15 | ..... | 15.28 | ..... | 0.38 | ..... |
| ..... | ..... | ..... | *0.22* | ..... | *14.80* | ..... | *0.03* | ..... | *14.83* | ..... | *0.60* | ..... |
| 2691 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 43.72 | **43.72** | 3.30 |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | *49.73* | *49.73* | ..... |
| 3723 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 49.24 | 49.24 | 1.08 |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | *49.46* | *49.46* | ..... |
| 3725 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 49.84 | 49.84 | 2.16 |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | *49.70* | *49.70* | ..... |
| 3738 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 44.92 | **44.92** | 3.56 |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | *49.19* | *49.19* | ..... |

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Pacific Guano and Fertilizer Co.**—*Continued.* | | |
| 3848 | Sulfate of Potash | C. C. Chapman, Fullerton | **50.38** |
| | *Guaranteed* | | *55.70* |
| 3941 | Sulfate of Potash | Sellers & Scofield, Glendora | 57.27 |
| | *Guaranteed* | | *56.54* |
| 4099* | Supergyp | Aubrey Frink, Fresno | 5.08 |
| 4106* | Supergyp | Stanislaus Farmers' Union, Modesto | 7.33 |
| | *Guaranteed* | | *5.17* |
| 4105 | Superphosphate | Stanislaus Farmers' Union, Modesto | 15.94 |
| 4012 | Superphosphate | Chula Vista L. G. Assn., Chula Vista | 16.73 |
| 4146 | Superphosphate | B. B. Meek, Oroville | 16.07 |
| 4210 | Superphosphate | Wright Bros., Riverside | 19.31 |
| | *Guaranteed* | | *15.98* |
| 4209 | Superphosphate | Wright Bros., Riverside | 19.21 |
| | *Guaranteed* | | *18.80* |
| 4118* | T | G. P. McNear, Petaluma | 27.91 |
| 4122* | T | Fair Oaks Fruit Co., Fair Oaks | 28.17 |
| | *Guaranteed* | | *28.46* |
| 3721* | Tankage | H. C. Rumohr, Redlands | 39.53 |
| | *Guaranteed* | | *38.44* |
| 3733* | Tankage | B. L. Byer, Upland | 37.84 |
| | *Guaranteed* | | *36.07* |
| 3958* | Tankage | H. C. Rumohr, Redlands | 38.20 |
| | *Guaranteed* | | *38.18* |
| 3967* | Tankage | N. S. Bater, Rialto | ..... |
| 3968* | Tankage | F. M. Lingo, Rialto | ..... |
| | *Sold on Station Analysis.* | | |
| 4193* | Tankage. | B. L. King, Covina | 46.25 |
| | *Guaranteed* | | *44.78* |
| | **Redlands Fertilizer Association, Redlands, Cal.** | | |
| 3650 | Blood | Factory, Redlands | 61.97 |
| | *Guaranteed* | | *62.07* |
| 3664 | Blood | Factory, Redlands | 57.96 |
| | *Guaranteed* | | *57.58* |
| 3925 | Blood | Factory, Redlands | 65.41 |
| | *Guaranteed* | | *63.72* |
| 3649* | Bone Meal | Factory, Redlands | 36.60 |
| | *Guaranteed* | | *37.40* |
| 3662* | Bone Meal | H. H. Garstin, Redlands | ..... |
| | *Sold on Station Analysis.* | | |
| 3690* | Bone Meal | Factory, Redlands | 37.06 |

*4099—Values stated do not include allowance for gypsum.

*4106—Values stated do not include allowance for gypsum.

*4118—Potash guaranteed 1% from muriate, 4% from sulfate.

*4122—Potash guaranteed 1% from muriate, 4% from sulfate.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 3848 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 44.20 | **44.20** | 3.76 |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | *48.86* | *48.86* | ..... |
| 3941 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 50.24 | 50.24 | 2.40 |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | *49.60* | *49.60* | ..... |
| 4099 | 5.41 | 8.44 | 13.85 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4106 | 7.80 | 5.00 | 12.80 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *5.50* | *7.00* | *12.50* | *Min. Phos.* | | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4105 | 16.96 | 0.24 | 17.20 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4012 | 17.80 | 0.40 | 18.20 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4146 | 17.10 | 0.40 | 17.50 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4210 | 20.54 | 0.46 | 21.00 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *17.00* | *1.00* | *18.00* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4209 | 20.44 | 0.46 | 20.90 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *20.00* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4118 | 6.90 | 2.00 | 8.90 | ..... | 2.55 | ..... | 1.45 | ..... | 4.00 | ..... | 4.57 | ..... |
| 4122 | 6.91 | 1.74 | 8.65 | ..... | 2.37 | ..... | 1.60 | ..... | 3.97 | ..... | 4.86 | ..... |
| ..... | *7.00* | *1.00* | *8.00* | *Super, Bn* | *2.00* | ..... | *2.00.* | *Bl, Bn, Fs* | *4.00* | ..... | *5.00* | ..... |
| 3721 | ..... | ..... | 9.90 | ..... | ..... | ..... | 7.02 | ..... | 7.02 | ..... | ..... | ..... |
| ..... | ..... | ..... | *9.47* | *Bl, Bn* | | ..... | *6.85* | *Bl, Bn* | *6.85* | ..... | ..... | ..... |
| 3733 | ..... | ..... | 16.75 | ..... | ..... | ..... | 5.51 | ..... | 5.51 | ..... | ..... | ..... |
| ..... | ..... | ..... | *16.27* | *Bn* | ..... | ..... | *5.20* | *Bl, Bn* | *5.20* | ..... | ..... | ..... |
| 3958 | ..... | ..... | 12.65 | ..... | ..... | ..... | 6.27 | ..... | 6.27 | ..... | ..... | ..... |
| ..... | ..... | ..... | *13.65* | *Bn* | ..... | ..... | *6.10* | *Bl, Bn* | *6.10* | ..... | ..... | ..... |
| 3967 | ..... | ..... | 14.45 | ..... | ..... | ..... | 6.60 | ..... | 6.60 | ..... | ..... | ..... |
| 3968 | ..... | ..... | 13.70 | ..... | ..... | ..... | 6.13 | ..... | 6.13 | ..... | ..... | ..... |
| 4193 | ..... | ..... | **10.10** | ..... | ..... | ..... | 8.46 | ..... | 8.46 | ..... | ..... | ..... |
| ..... | ..... | ..... | *12.00* | *Bn* | ..... | ..... | *7.82* | *Bl, Bn* | *7.82* | ..... | ..... | ..... |
| 3650 | ..... | ..... | ..... | ..... | ..... | ..... | 13.13 | ..... | 13.13 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.15* | ..... | *13.15* | ..... | ..... | ..... |
| 3664 | ..... | ..... | ..... | ..... | ..... | ..... | 12.28 | ..... | 12.28 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *12.20* | ..... | *12.20* | ..... | ..... | ..... |
| 3925 | ..... | ..... | ..... | ..... | ..... | ..... | 13.86 | ..... | 13.86 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.50* | ..... | *13.50* | ..... | ..... | ..... |
| 3649 | ..... | ..... | 28.90 | ..... | ..... | ..... | 1.69 | ..... | **1.69** | ..... | ..... | ..... |
| ..... | ..... | ..... | *26.00* | ..... | ..... | ..... | *2.50* | ..... | *2.50* | ..... | ..... | ..... |
| 3662 | ..... | ..... | 24.10 | ..... | ..... | ..... | 3.28 | ..... | 3.28 | ..... | ..... | ..... |
| 3690 | ..... | ..... | 33.00 | ..... | ..... | ..... | 0.89 | ..... | **0.89** | ..... | ..... | ..... |

*3721—93% fine. *3967—86% fine. *3649—77% fine.
*3733—75% fine. *3968—83% fine. *3662—65% fine.
*3958—71% fine. *4193—70% fine. *3690—91% fine.

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Redlands Fertilizer Association** *—Continued.* | | |
| 3930* | Bone Meal | Factory, Redlands | 38.40 |
| | *Guaranteed* | | *35.84* |
| 3931* | Bone Meal | Factory, Redlands | 37.03 |
| | *Guaranteed* | | *38.68* |
| 3926 | Nitrate of Soda | Factory, Redlands | 43.93 |
| | *Guaranteed* | | *42.30* |
| 3661 | Sulfate of Potash | Factory, Redlands | **50.57** |
| | *Guaranteed* | | *55.40* |
| 3653* | Tankage | Factory, Redlands | 41.95 |
| | *Guaranteed* | | *42.97* |
| 3668* | Tankage | Factory, Redlands | 33.36 |
| | *Guaranteed* | | *34.66* |
| 3928* | Tankage | Factory, Redlands | 45.02 |
| | *Guaranteed* | | *44.61* |
| 3929* | Tankage | Factory, Redlands | 47.00 |
| | *Guaranteed* | | *48.62* |
| 4039* | Tankage | C. F. Woehr, Redlands | 48.84 |
| | *Guaranteed* | | *49.23* |
| | **Redlands Fruit Association, Redlands, Cal.** | | |
| 3973 | Blood and Meat | Mrs. Elizabeth Arth, Redlands | **49.52** |
| | *Guaranteed* | | *54.72* |
| 3975* | Bone Meal | W. C. Warner, Redlands | 41.91 |
| | *Guaranteed* | | *41.98* |
| 3755 | Royal Knight Summer | Factory, Redlands | 27.01 |
| | *Guaranteed* | | *27.91* |
| | **Standard Rendering Co., Kansas City, Mo.** | | |
| 3688* | Standard Bone | C. C. Chapman, Fullerton | 35.79 |
| | *Guaranteed* | | *36.74* |
| 3628* | Standard One | Corona Lemon Co., Corona | 41.27 |
| 3654* | Standard One | Corona Lemon Co., Corona | 42.15 |
| 3692* | Standard One | Benchley Fruit Co., Fullerton | 40.94 |
| 3699* | Standard One | Windermere Ranch, LaMirada | 41.59 |
| 3784* | Standard One | F. D. Parker, Hollywood | 41.95 |

*3930—82% fine.
*3931—53% fine.
*3653—76% fine.
*3668—72% fine. A mixture of bat guano and tankage.
*3928—72% fine.
*3929—70% fine.
*4039—67% fine.
*3975—47% fine.
*3688—59% fine.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 3930 | ..... | ..... | 28.60 | ..... | ..... | ..... | 2.15 | ..... | 2.15 | ..... | ..... | ..... |
| ..... | ..... | ..... | *29.00* | ..... | ..... | ..... | *1.50* | ..... | *1.50* | ..... | ..... | ..... |
| 3931 | ..... | ..... | 24.40 | ..... | ..... | ..... | 2.77 | ..... | 2.77 | ..... | ..... | ..... |
| ..... | ..... | ..... | *25.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 3926 | ..... | ..... | ..... | ..... | 15.58 | ..... | ..... | ..... | 15.58 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... |
| 3661 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 44.36 | **44.36** | 2.94 |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | *48.60* | *48.60* | ..... |
| 3653 | ..... | ..... | 11.40 | ..... | ..... | ..... | 7.30 | ..... | 7.30 | ..... | ..... | ..... |
| ..... | ..... | ..... | *11.90* | *Bn* | ..... | ..... | *7.44* | *Bl, Bn* | *7.44* | ..... | ..... | ..... |
| 3668 | ..... | ..... | **11.55** | ..... | ..... | ..... | 5.39 | ..... | 5.39 | ..... | ..... | ..... |
| ..... | ..... | ..... | *13.50* | *Bn* | ..... | ..... | *5.35* | *Bl, Bn* | *5.35* | ..... | ..... | ..... |
| 3928 | ..... | ..... | 11.00 | ..... | ..... | ..... | 8.04 | ..... | 8.04 | ..... | ..... | ..... |
| ..... | ..... | ..... | *11.92* | *Bn* | ..... | ..... | *7.80* | *Bl, Bn* | *7.80* | ..... | ..... | ..... |
| 3929 | ..... | ..... | 10.80 | ..... | ..... | ..... | 8.51 | ..... | **8.51** | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.58* | *Bn* | ..... | ..... | *8.90* | *Bl, Bn* | *8.90* | ..... | ..... | ..... |
| 4039 | ..... | ..... | 5.65 | ..... | ..... | ..... | 9.77 | ..... | 9.77 | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.50* | *Bn* | ..... | ..... | *9.88* | *Bl, Bn* | *9.88* | ..... | ..... | ..... |
| 3973 | ..... | ..... | ..... | ..... | ..... | ..... | 10.86 | ..... | **10.86** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *12.00* | ..... | *12.00* | ..... | ..... | ..... |
| 3975 | ..... | ..... | **26.00** | ..... | ..... | ..... | 3.49 | ..... | 3.49 | ..... | ..... | ..... |
| ..... | ..... | ..... | *28.85* | ..... | ..... | ..... | *2.88* | ..... | *2.88* | ..... | ..... | ..... |
| 3755 | 7.86 | 2.64 | 10.50 | ..... | 1.26 | 0.20 | 1.29 | ..... | 2.75 | 5.59 | 5.59 | ..... |
| ..... | *5.00* | *5.00* | *10.00* | *Bn, G* | *1.50* | ..... | *1.50* | *Bl, Bn G, T* | *3.00* | *6.00* | *6.00* | ..... |
| 3688 | ..... | ..... | **31.00** | ..... | ..... | ..... | 1.05 | ..... | 1.05 | ..... | ..... | ..... |
| ..... | ..... | ..... | *34.00* | ..... | ..... | ..... | *0.60* | ..... | *0.60* | ..... | ..... | ..... |
| 3628 | ..... | ..... | 21.25 | ..... | ..... | ..... | 4.39 | ..... | 4.39 | ..... | ..... | ..... |
| 3654 | ..... | ..... | 22.45 | ..... | ..... | ..... | 4.32 | ..... | 4.32 | ..... | ..... | ..... |
| 3692 | ..... | ..... | 21.10 | ..... | ..... | ..... | 4.35 | ..... | 4.35 | ..... | ..... | ..... |
| 3699 | ..... | ..... | 21.80 | ..... | ..... | ..... | 4.34 | ..... | 4.34 | ..... | ..... | ..... |
| 3784 | ..... | ..... | 21.70 | ..... | ..... | ..... | 4.44 | ..... | 4.44 | ..... | ..... | ..... |

*3628—82% fine.
*3654—80% fine.
*3692—91% fine.
*3699—80% fine.
*3784—83% fine.

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Standard Rendering Co.—** *Continued.* | | |
| 3901* | Standard One | V. H. Craig, Los Angeles | 40.23 |
| 3966* | Standard One | V. H. Craig, Los Angeles | 40.46 |
| 4001* | Standard One | Azusa Citrus Association, Azusa | 41.23 |
| 4002* | Standard One | Azusa Citrus Association, Azusa | 41.07 |
| 4034* | Standard One | R. C. McGill, La Mirada | 41.03 |
| 4225* | Standard One | Windermere Ranch, La Mirada | 40.90 |
| 4231* | Standard One | Windermere Ranch, La Mirada | 41.74 |
| | *Guaranteed* | | *38.77* |
| | **Standard Supply Co., Los Angeles, Cal.** | | |
| 3890 | Bat Guano | Glendora Citrus Assn., Glendora | ..... |
| | *Sold on Station Analysis.* | | |
| 4215 | No. 1 | Factory, Los Angeles | 17.19 |
| | *Guaranteed* | | *15.64* |
| 4214 | No. 2 | Factory, Los Angeles | 22.63 |
| | *Guaranteed* | | *23.56* |
| 4216 | No. 4 | Factory, Los Angeles | 25.22 |
| | *Guaranteed* | | *22.86* |
| 4218 | Superphosphate | Factory, Los Angeles | 16.62 |
| | *Guaranteed* | | *15.98* |
| 4217* | Tankage | Factory, Los Angeles | 14.40 |
| | *Guaranteed* | | *16.40* |
| | **Swift & Co., Chicago, Ill.** | | |
| 3697* | Bone Meal | E. L. Koethen, Riverside | 38.77 |
| 3902* | Bone Meal | G. W. Duley, Upland | 38.77 |
| | *Guaranteed* | | *37.52* |
| 3822 | Diamond D | P. E. Stanton, Covina | **28.46** |
| 3843 | Diamond D | P. E. Stanton, Covina | 38.92 |
| | *Guaranteed* | | *37.88* |
| 3620* | Diamond E | Redlands Fertilizer Assn., Redlands | 36.04 |
| 3652* | Diamond E | Redlands Fertilizer Assn., Redlands | 36.16 |
| | *Guaranteed* | | *36.10* |
| 3821* | Special Bone Meal | P. E. Stanton, Covina | 33.32 |
| | *Guaranteed* | | *32.74* |

These samples originally classified as bone meals and the fineness was reported on this basis.

*3901—82% fine.
*3966—85% fine.
*4001—85% fine.
*4002—82% fine.

Classified in this bulletin as tankage with the corresponding determination of fineness.

*4034—82% fine.
*4225—82% fine.
*4231—80% fine.
*4217—98% fine. Mislabeled. Contains added potash salts.
*3697—63% fine.
*3902—80% fine.
*3620—87% fine.
*3652—86% fine.
*3821—57% fine.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 3901 | ..... | ..... | 20.80 | ..... | ..... | ..... | 4.26 | ..... | 4.26 | ..... | ..... | ..... |
| 3966 | ..... | ..... | 20.95 | ..... | ..... | ..... | 4.28 | ..... | 4.28 | ..... | ..... | ..... |
| 4001 | ..... | ..... | 21.30 | ..... | ..... | ..... | 4.37 | ..... | 4.37 | ..... | ..... | ..... |
| 4002 | ..... | ..... | 21.60 | ..... | ..... | ..... | 4.27 | ..... | 4.27 | ..... | ..... | ..... |
| 4034 | ..... | ..... | 21.65 | ..... | ..... | ..... | 4.25 | ..... | 4.25 | ..... | ..... | ..... |
| 4225 | ..... | ..... | 21.20 | ..... | ..... | ..... | 4.32 | ..... | 4.32 | ..... | ..... | ..... |
| 4231 | ..... | ..... | 22.00 | ..... | ..... | ..... | 4.33 | ..... | 4.33 | ..... | ..... | ..... |
| ..... | ..... | ..... | *18.25* | *Bn, T* | ..... | ..... | *4.50* | *Bn, T* | *4.50* | ..... | ..... | ..... |
| 3890 | ..... | ..... | 3.40 | ..... | 5.47 | 1.38 | 6.95 | ..... | 13.80 | ..... | 1.58 | ..... |
| 4215 | 4.69 | 0.36 | 5.05 | ..... | 3.27 | ..... | ..... | ..... | 3.27 | 3.12 | 3.12 | 0.60 |
| ..... | *4.00* | *1.00* | *5.00* | *Super,* | *3.00* | ..... | ..... | ..... | *3.00* | *3.00* | *3.00* | ..... |
| 4214 | 4.83 | 2.72 | 7.55 | ..... | 4.37 | ..... | ..... | ..... | 4.37 | 5.06 | 5.06 | 0.60 |
| ..... | ..... | ..... | *7.00* | *Super* | *4.00* | ..... | ..... | ..... | *4.00* | *5.00* | *5.00* | ..... |
| 4216 | 9.62 | 0.08 | 9.70 | ..... | 4.27 | ..... | ..... | ..... | 4.27 | 3.61 | 3.61 | ..... |
| ..... | *9.00* | *1.00* | *10.00* | *Super* | *4.50* | ..... | ..... | ..... | *4.50* | *1.50* | *1.50* | ..... |
| 4218 | 17.68 | 0.32 | 18.00 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *17.00* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 4217 | ..... | ..... | 4.70 | ..... | ..... | ..... | 2.08 | ..... | **2.08** | 1.18 | 1.18 | ..... |
| ..... | ..... | ..... | *5.50* | *Bn* | ..... | ..... | *2.43* | *Bl, Bn* | *2.43* | *1.00* | *1.00* | ..... |
| 3697 | ..... | ..... | 29.60 | ..... | ..... | ..... | 2.01 | ..... | 2.01 | ..... | ..... | ..... |
| 3902 | ..... | ..... | 29.10 | ..... | ..... | ..... | 2.12 | ..... | 2.12 | ..... | ..... | ..... |
| ..... | ..... | ..... | *30.00* | ..... | ..... | ..... | *1.65* | ..... | *1.65* | ..... | ..... | ..... |
| 3822 | ..... | ..... | 22.50 | ..... | ..... | ..... | 0.86 | ..... | **0.86** | 1.79 | **1.79** | ..... |
| 3843 | ..... | ..... | 20.90 | ..... | ..... | ..... | 1.99 | ..... | 1.99 | ..... | **7.85** | 2.00 |
| ..... | ..... | ..... | *19.00* | *Bn* | ..... | ..... | *1.64* | *Bn* | *1.64* | *10.00* | *10.00* | ..... |
| 3620 | ..... | ..... | 18.80 | ..... | ..... | ..... | 4.77 | ..... | 4.77 | ..... | ..... | ..... |
| 3652 | ..... | ..... | 19.00 | ..... | ..... | ..... | 4.77 | ..... | 4.77 | ..... | ..... | ..... |
| ..... | ..... | ..... | *17.50* | *Bn* | ..... | ..... | *5.00* | *Bl, Bn* | *5.00* | ..... | ..... | ..... |
| 3821 | ..... | ..... | 28.30 | ..... | ..... | ..... | 1.10 | ..... | 1.10 | ..... | ..... | ..... |
| ..... | ..... | ..... | *29.00* | ..... | ..... | ..... | *0.82* | ..... | *0.82* | ..... | ..... | ..... |

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Swift & Co.—Continued.** | | |
| 3665* | Tankage | Redlands Fertilizer Assn., Redlands | 43.97 |
| 3927* | Tankage | Redlands Fertilizer Assn., Redlands | 45.86 |
| | *Guaranteed* | | *44.84* |
| 3660 | *3–12–6* | Redlands Fertilizer Assn., Redlands | 32.77 |
| | *Guaranteed* | | *32.52* |
| | **Union Fertilizer Co., Los Angeles, Cal.** | | |
| 3640 | Fruiting | C. H. Tyler, Pomona | 22.98 |
| 3641 | Fruiting | C. H. Tyler, Pomona | 24.47 |
| 3740 | Fruiting | G. H. Dole, Riverside | 22.54 |
| 3782 | Fruiting | C. D. Hubbard, San Fernando | 25.95 |
| 3816 | Fruiting | Bloomington Fruit Assn., Bloomington | 25.23 |
| 3907 | Fruiting | J. F. Jackson, Riverside | 22.77 |
| 3938 | Fruiting | E. E. Cole, Redlands | 26.08 |
| | *Guaranteed* | | *23.70* |
| 3655 | Nitrate of Soda | W. A. Hively, Corona | 43.06 |
| 3937 | Nitrate of Soda | E. E. Cole, Redlands | 43.44 |
| | *Guaranteed* | | *42.30* |
| 3643 | Nursery | C. H. Tyler, Pomona | 28.84 |
| 3644 | Nursery | C. H. Tyler, Pomona | 27.95 |
| 3783 | Nursery | C. D. Hubbard, San Fernando | 25.95 |
| 3908 | Nursery | J. F. Jackson, Riverside | 29.21 |
| | *Guaranteed* | | *29.29* |
| 3642* | Special | C. H. Tyler, Pomona | ..... |
| | *Guaranteed* | | ..... |
| 3675 | Special | A. T. Hansen, Pasadena | 25.28 |
| | *Guaranteed* | | *23.87* |
| 3656 | Special Fruiting | W. A. Hiveley, Corona | 27.63 |
| | *Guaranteed* | | *29.25* |
| | **Union Superphosphate Co., San Francisco, Cal.** | | |
| 3663 | Superphosphate | Redlands Fertilizer Assn., Redlands | 16.83 |
| | *Guaranteed* | | *16.54* |

*3665—71% fine.
*3927—80% fine.

*3642—Mislabeled. Statement of derivation false. This material is Bird Guano Phosphate.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 3665 | ..... | ..... | 6.25 | ..... | ..... | ..... | 8.60 | ..... | **8.60** | ..... | ..... | ..... |
| 3927 | ..... | ..... | 7.25 | ..... | ..... | ..... | 8.85 | ..... | 8.85 | .... | ..... | ..... |
| ..... | ..... | ..... | *5.00* | *Bn* | ..... | ..... | *9.00* | *Bl, Bn* | *9.00* | ..... | ..... | ..... |
| 3660 | ..... | ..... | 12.85 | ..... | ..... | ..... | 2.86 | ..... | 2.86 | 6.04 | 6.04 | 0.60 |
| ..... | ..... | ..... | *12.00* | *Bn* | ..... | ..... | *3.00* | *Bl, Bn* | *3.00* | *6.00* | *6.00* | ..... |
| 3640 | 6.50 | 1.20 | 7.70 | ..... | 1.87 | ..... | 1.35 | ..... | 3.22 | 3.38 | 3.38 | 0.70 |
| 3641 | 7.48 | 1.42 | 8.90 | ..... | 1.14 | 0.56 | 1.41 | ..... | 3.11 | 3.44 | 3.44 | ..... |
| 3740 | 7.90 | 1.10 | 9.00 | ..... | 1.78 | 0.15 | 1.10 | ..... | 3.03 | 2.60 | 2.60 | 0.65 |
| 3782 | 8.21 | 1.14 | 9.35 | ..... | 1.04 | 0.84 | 1.42 | ..... | 3.30 | 3.68 | 3.68 | 0.75 |
| 3816 | 7.96 | 1.34 | 9.30 | ..... | 0.90 | 0.48 | 1.86 | ..... | 3.24 | 2.81 | 2.81 | 1.07 |
| 3907 | 6.95 | 0.95 | 7.90 | ..... | 1.66 | 0.15 | 1.39 | ..... | 3.20 | 2.91 | 2.91 | 0.75 |
| 3938 | 8.73 | 1.72 | 10.45 | ..... | 1.31 | 0.20 | 1.57 | ..... | 3.08 | 3.56 | 3.56 | 0.80 |
| ..... | *7.00* | *1.50* | *8.50* | *Super, Bn, G, T* | *0.75* | *0.60* | *1.65* | *Bn, G, T* | *3.00* | *3.00* | *3.00* | ..... |
| 3655 | ..... | ..... | ..... | ..... | 15.27 | ..... | ..... | ..... | 15.27 | ..... | ..... | ..... |
| 3937 | ..... | ..... | ..... | ..... | 15.41 | ..... | ..... | ..... | 15.41 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... |
| 3643 | 6.38 | 1.12 | 7.50 | ..... | 2.10 | 0.76 | 2.30 | ..... | 5.16 | 1.94 | 1.94 | ..... |
| 3644 | 6.11 | 0.94 | 7.05 | ..... | 2.03 | 0.79 | 2.20 | ..... | 5.02 | 2.03 | 2.03 | 0.87 |
| 3783 | 6.30 | 1.20 | 7.50 | ..... | 2.30 | 0.92 | 2.18 | ..... | 5.40 | 2.14 | 2.14 | 0.75 |
| 3908 | 6.36 | 0.84 | 7.20 | ..... | 2.05 | 0.40 | 2.75 | ..... | 5.20 | 1.98 | 1.98 | 0.83 |
| ..... | *6.00* | *1.50* | *7.50* | *Super Bn, G, T* | *1.00* | *1.00* | *3.00* | *Bn, G, T* | *5.00* | *1.50* | *1.50* | ..... |
| 3642 | 12.90 | 23.80 | 36.70 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *12.00* | *23.00* | *35.00* | *Super, Bn, G* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3675 | 5.43 | 1.12 | 6.55 | ..... | 1.52 | 0.65 | 1.94 | ..... | 4.11 | 2.86 | 2.86 | 0.92 |
| ..... | *5.50* | ..... | ..... | *Super, Bn, G* | *1.00* | *1.00* | *2.00* | *Bl, Bn, G, T* | *4.00* | *2.50* | *2.50* | ..... |
| 3656 | 8.60 | 1.10 | 9.70 | ..... | 2.05 | 0.67 | 1.33 | ..... | 4.05 | 3.24 | 3.24 | 0.75 |
| ..... | *8.00* | *1.50* | *9.50* | *Super, Bn, G T* | *1.00* | *0.75* | *2.25* | *Bn, G, T* | *4.00* | *3.50* | *3.50* | ..... |
| 3663 | 17.90 | 0.30 | 18.20 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *17.60* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

## ANALYSES AND VALUATIONS—Continued.

| Laboratory Number. | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Western Meat Co., San Francisco, Cal.** | | |
| 4114 | Gold Bear (B) | Sebastopol Berry Grs., Sebastopol | 32.46 |
| | *Guaranteed* | | *34.11* |
| 4115 | Gold Bear (C) | Sebastopol Berry Grs. Sebastopol | 32.69 |
| | *Guaranteed* | | *31.09* |
| 3651* | Diamond E | Redlands Fertilizer Assn., Redlands | 34.75 |
| 4163* | Diamond E | J. S. Grepe, East Highland | **33.72** |
| | *Guaranteed* | | *36.40* |
| 4165 | Diamond H | Redlands Fertilizer Assn., Redlands | **57.8**[illegible] |
| | *Guaranteed* | | *60.18* |
| 4178* | Diamond I | Redlands Fertilizer Assn., Redlands | 34.42 |
| | *Guaranteed* | | *34.84* |
| | **Woodbridge Fertilizer Co., Los Angeles, Cal.** | | |
| 3864* | | San Dimas Citrus Nurseries, San Dimas | 19.66 |
| | *Guaranteed* | | *18.34* |
| 3923* | | Factory, San Bernardino | 20.99 |
| | *Guaranteed* | | *19.06* |
| 3924* | | Factory, San Bernardino | 20.11 |
| | *Guaranteed* | | *18.86* |
| 4029 | Superphosphate | T. E. Yerxa Ranch, Highland | 16.22 |
| | *Guaranteed* | | *16.13* |
| 3808 | Woodbridge Young Trees | C. C. Fisher, Rialto | 29.70 |
| | *Guaranteed* | | *28.58* |

*3651—80% fine.
*4163—82% fine.
*4178—75% fine.
*3864—No brand name as required by Fertilizer Act.
*3923—No brand name as required by Fertilizer Act.
*3924—No brand name as required by Fertilizer Act.

## ANALYSES AND VALUATIONS—Continued.

POUNDS PER HUNDRED.

| Laboratory Number. | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available. | Insoluble. | Total. | Guaranteed as derived from. | In Nitrates. | In Ammonia Salts. | Organic. | Organic Nitrogen guaranteed as derived from. | Total. | From Sulfate. | Total. | |
| 4114 | 10.10 | 2.40 | 12.50 | ..... | ..... | ..... | 2.30 | ..... | 2.30 | 8.31 | **8.31** | 1.10 |
| ..... | *9.00* | *2.50* | *11.50* | *Super, Bn* | ..... | ..... | *2.46* | *Bl, Bn* | *2.46* | *10.00* | *10.00* | ..... |
| 4115 | 7.51 | 2.34 | 9.85 | ..... | ..... | ..... | 3.37 | ..... | 3.37 | 6.55 | 6.55 | 1.30 |
| ..... | *7.00* | *2.25* | *9.25* | *Super, Bn* | ..... | ..... | *3.29* | *Bl, Bn* | *3.29* | *6.00* | *6.00* | ..... |
| 3651 | ..... | ..... | **16.15** | ..... | ..... | ..... | 4.93 | ..... | 4.93 | ..... | ..... | ..... |
| 4163 | ..... | ..... | 19.30 | ..... | ..... | ..... | 4.18 | ..... | **4.18** | ..... | ..... | ..... |
| ..... | ..... | ..... | *18.32* | *Bn* | ..... | ..... | *4.93* | *Bl, Bn* | *4.93* | ..... | ..... | ..... |
| 4165 | ..... | ..... | ..... | ..... | ..... | ..... | 12.25 | ..... | **12.25** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *12.75* | *Blood* | *12.75* | ..... | ..... | ..... |
| 4178 | ..... | ..... | 14.40 | ..... | ..... | ..... | 5.15 | ..... | 5.15 | ..... | ..... | ..... |
| ..... | ..... | ..... | *13.75* | *Bn* | ..... | ..... | *5.35* | *Bl, Bn* | *5.35* | ..... | ..... | ..... |
| 3864 | 7.01 | 1.14 | 8.15 | ..... | 2.12 | ..... | ..... | ..... | 2.12 | 4.86 | 4.86 | 0.80 |
| ..... | ..... | ..... | *7.00* | *Super, Bn* | *2.00* | ..... | ..... | ..... | *2.00* | *5.00* | *5.00* | ..... |
| 3923 | 6.69 | 0.66 | 7.35 | ..... | 2.25 | ..... | ..... | ..... | 2.25 | 6.80 | 6.80 | 0.90 |
| ..... | ..... | ..... | *7.00* | *Super, Bn* | *2.00* | ..... | ..... | ..... | *2.00* | *6.00* | *6.00* | ..... |
| 3924 | 7.96 | 0.64 | 8.60 | ..... | 2.00 | ..... | ..... | ..... | 2.00 | 5.61 | 5.61 | 0.65 |
| ..... | ..... | ..... | *8.00* | *Super, Bn* | *2.00* | ..... | ..... | ..... | *2.00* | *5.00* | *5.00* | ..... |
| 4029 | 17.26 | 0.24 | 17.50 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *17.17* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3808 | 11.90 | 0.50 | 12.40 | ..... | ..... | ..... | ..... | ..... | ..... | 16.25 | 16.25 | 0.90 |
| ..... | ..... | ..... | *11.00* | *Super, Bn* | ..... | ..... | ..... | ..... | ..... | *16.00* | *16.00* | ..... |

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# HUMUS IN CALIFORNIA SOILS

BY

R. H. LOUGHRIDGE

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# HUMUS IN CALIFORNIA SOILS.

By R. H. Loughridge.

## INTRODUCTION.

### Examinations of California Soils.

Information and data regarding the nature of the soils of the State have been obtained through the physical and chemical analyses of thousands of samples taken according to our directions and sent to our laboratory by farmers throughout California; by the examination of samples of a few feet in depth taken by us or other members of the station staff; and of one hundred soil columns taken to depths of ten or twelve feet from each of the main soil regions of the State, chiefly by the author and his assistant, the late F. E. Johnson.

It has been the policy of the California Experiment Station, from the time when Professor Hilgard established it in 1875 to the present time, to respond to the call of farmers for information regarding problems of the farm in all of its branches, and especially those of the soil and its products. The examination of soils has been free to the farmer, and during these years many thousands of samples of soil have been sent to us by them to ascertain whether there be a lack of plant food and a need of fertilizers, whether alkali salts be present and how gotten rid of, or whether there be some other causes of infertility. The samples were for the most part taken according to our directions, and examined as to their physical properties, and as to the approximate amount of humus, lime, and phosphoric acid, and sometimes of potash, short methods for these determinations having been adopted. Where alkali was found to be present in any appreciable amount, the percentage of each salt was determined by a regular analysis.

These examinations of soils that came from every part of the State, together with such personal visits as Professor Hilgard and the author were able to make to the main agricultural regions, gave an excellent insight into the agricultural conditions of every part of the State; which has been of very great importance in our work and a special help toward the completion of a soil map of the State, there being no funds available for the prosecution of a soil survey.

While this work consumed much of the time that we would have preferred to give to research, we believe that it has been of value to those concerned and especially to the station, by bringing it and the farmer into close touch with each other.

### The Nature of Humus and its Formation.

The name humus should not be applied to all of the vegetable matter of the soil in all stages of decay, as many seem to think, but only to a peculiar product of partial decay of vegetable and animal matters

brought about under conditions of moisture, warmth, a limited amount of air and in the presence of lime. Until humification of the leaves, roots and other plant débris takes place the beneficial effects of humus itself are not obtained, and the material, while loosening the soil (sometimes injuriously), is practically inert as far as enriching the soil with its nitrogen and mineral elements is concerned. This was shown by the experiments of Professor Hilgard, carried on through a period of two years. (Soils, page 359.)

Humus contains all of the decomposition products of both vegetable and animal matters, and therefore includes at least minute quantities of amido, amin, and purin compounds, most of which are beneficial and some are injurious to vegetation.

Humus is so thoroughly disseminated in the soil that its presence is noticeable only in the dark color it gives when in large amounts. It is black or brown in color, resembling charcoal in its lightness and porosity as well as in its destructibility by fire. It is colloidal in nature and though derived from vegetable matter, it has lost all of the fibrous and cellular structure of plants. It is highly absorbent of gases and of moisture in the latter case, swelling to eight to fourteen times its dry volume.

Humus has no definite composition beyond the fact that it is made up of the same elements that enter into the composition of plants—carbon, oxygen, hydrogen, nitrogen, and some mineral elements. The proportion of carbon is, however, greater than in plants because of the partial decay. Humus is really a mixture of compounds in proportions that vary with the nature of the substance from which it was obtained, and from a mixture of different substances in the soil. This is especially true with regard to the nitrogen—the most valuable element in humus. Some organic substances are almost lacking in nitrogen and yield a humus containing but little of it, while, on the other hand, a humus may be extremely rich in nitrogen because derived from substances very rich in that element.

In a soil humus is usually combined with lime and other elements as humates, and is then not soluble in water, but is dissolved by a solution of caustic alkali and of carbonate of soda, thus giving rise to the name "black alkali." In soils that are weak in lime it often occurs as free humic acid, and is then soluble in water and causes injurious acidity in soils, which must be counteracted by the application of lime. By the action of air and bacteria it is slowly destroyed and carbonic acid, water and ammonia are produced. Free humic acid is frequently produced by the growing of lime-loving plants, such as alfalfa and other legumes, the lime being absorbed by many successive crops and the humus left behind as humic acid. This has taken place in the Eel River Valley soils of Humboldt County, California, and only the application of lime has restored the land to its former fertility.

*Amount of Humus Formed from Vegetable Matter.* With regard to the amount of humus formed from the decay of vegetable matter, Professor Hilgard says (Soils, page 128): "Only very general and indefinite estimates can be given of the amount of humus formed from a given amount of vegetable matter, since these must vary according to the conditions under which the transformation occurs. The greater or less access of air and of moisture, the temperature and pressure under which the process occurs, will modify very materially the quantitative as well as the qualitative result. In the hot, arid regions the fallen leaves may wholly disappear by oxidation on the surface of the ground, while under humid conditions they are mostly incorporated with the surface soil. If we assume that in the humification of plant débris no nitrogen is lost, it would seem that in the humid region one part of normal soil humus might be formed from five to six parts of dry plant débris; while in the extreme régime of the arid regions from eighteen to twenty parts of the same would be required. But as most probably some nitrogen is lost in the process of humification, a considerably larger proportion of original substance may be actually required."

Professor Snyder of the Minnesota Experiment Station by his experiments (Bulletin 53) obtained the following results: One part of humus to 32.7 parts of fresh cow manure, or 24.5 parts of green clover, or 10.8 of meat scraps; the humus of the cow manure contained 6.16 per cent of nitrogen, that of the clover 8.24 per cent and that of meat scraps 10.96 per cent. Oat straw and sawdust remained in the ground apparently unchanged for more than a year, but finally gave one part of humus for 5.5 parts of straw and for 9.5 of sawdust, respectively; the humus of the straw had 2.5 per cent of nitrogen and that of the sawdust only 0.3 per cent. In the drier soils of California the straw and sawdust would doubtless remain unchanged for several years.

### Value of Humus.

The great value of humus to the soils of this State is not as well recognized generally by farmers as it should be, and they probably do not fully realize that by maintaining a proper supply in the soil through a careful system of green-manuring they will avoid the expense of hundreds of dollars worth of nitrogen, that most expensive of fertilizers, and at the same time keep the soil in a splendid physical condition not produced by fertilizers alone.

Potash, phosphoric acid and nitrogen have their beneficial effect only in maintaining the growth and productiveness of plants and do not affect the soil itself materially; lime influences the structural formation of the plant, the character of the fruit, the physical condition of soils, and neutralizes any acid condition. But humus goes still farther by not only supplying important and expensive elements of food to the

plant and producing excellent mechanical conditions in the soil, but by influencing the life and activity of important bacteria. The following is a brief summary of the value of humus:

*Humus Improves the Texture of Soils.* It does this in clay soils by causing aggregation or flocculation of the particles of clay into a granular condition, thus producing looseness and easier tillage. The soil is thus better *aerated* and *ventilated*, and is made *warmer* for plant development. By this condition it is made more *receptive for rainfall*, permits greater freedom in the downward percolation of water, and prevents its evaporation by the sun's heat. When incorporated with loose sandy soils it occupies the spaces between the grains, thus binding the sand together, and giving better texture. By this the soil is made to hold moisture which would otherwise be lost by percolation and by evaporation; and it is made cooler in summer because of absorption and radiation of the heat from the black particles. It decreases the conductivity of a sandy soil for heat, thus preventing overheating of surface plant roots in such soils.

*Humus Largely Prevents the Crusting of Soil Surfaces.* One of the troubles that California farmers have to contend with is the tendency of the soil to become crusted over or compacted after a rainfall or after irrigation. This seems to be quite general throughout the State, and we believe is in part due to insufficiency of humus and of other vegetable matter which would maintain a granular structure in the soil. An intermixture of well-rotted stable or farmyard manure would also tend to prevent the crusting, but the turning under and humification of suitable green-manure crops until the amount of humus produced reached several per cent would be better and more permanent.

*Humus in the Soil Absorbs Water and Water Vapor.* This is due to its porosity, which gives to it a very high absorptive power. But it does this only in its diffused colloidal condition in the soil. When separated from the soil and dried at a low temperature it loses its colloidal nature and acts only as so much fine silt.

*Humus Promotes Chemical Action in the Soil.* The humus acts upon the inert and insoluble minerals in the soil and slowly renders their elements of plant-food available for plant use.

According to Prof. Harry Snyder of Minnesota,* it is only the humus that contains a high percentage of nitrogen that acts most energetically upon the inert mineral matter, and he designates this as "active humus," while that with low content of nitrogen he classes as "inactive humus."

*Humus Contains Nitrogen and is a Nitrogen Fertilizer.* Nitrogen exists in the soil partly in the free state in the air that permeates the soil mass; partly in the vegetable and animal material that has not

*See Chemistry of Soils and Fertilizers, page 100.

undergone humification; partly in the humified vegetable and animal matter in water, and hence very variable in amount from day to day and liable to be lost by drainage. That the unhumified material in the soil does not yield its nitrogen to plants until after complete humification has been shown by the experiments of Professor Hilgard, whose conclusions are as follows: "It thus appears that although the nitrogen of the unhumified organic matter constituted about 40 per cent of the total in the original soil, it would during the entire year have contributed only to an insignificant extent to the available nitrate supply; while the fully humified 'matiere noire' contributed fourteen times as much. During the growing season of four or five months the unhumified organic matter would have yielded practically nothing to the crop." (Soils, page 360.)

The humus itself then is the most reliable source of nitrogen, keeping it in reserve, to be given to the roots of plants by degrees, by ammonifying and nitrifying bacteria and at the same time when most needed, viz, in the growing season. The fertilizing value of humus depends, as has already been remarked, upon the amount of nitrogen that it contains and which may be changed to ammonia and nitrates through the agency of bacteria and given to the soil and plant. The nitrogen content naturally varies according to the nature of the materials from which the humus was formed and to any diminution that may have occurred from bacterial action or other causes, and we therefore find great differences in one and the same column of soil. Sometimes the difference is very great between one foot and the next below, for which it is difficult to account.

This humus nitrogen is not, so far as we know, directly available to plants, except in minute quantities of soluble amido compounds formed by the decay of nitrogenous matter, but becomes so through the action of ammonifying and nitrifying bacteria in the soil, which convert it into nitrates.

The humus, therefore, is a valuable source of nitrogen for plant use, and at the same time is a cheap source, because a crop of legumes can be grown at but the small expense of growing, cutting, and plowing under. The percentage of nitrogen that humus contains varies in California from a little more than one per cent in the desert sagebrush lands to as much as twenty per cent in better lands; the average is from five to six per cent.

*Humus Contains Soluble Mineral Plant-food.* When humus is separated from the soil and burned it leaves an ash which contains large percentages of potash, soda, phosphoric acid and lime, which while in combination with humus are regarded as being immediately available for plant use. While the amount thus contained in the soil is not large,

varying from .01 to .05 per cent of potash and of phosphoric acid, it adds very materially to the fertility of the soil, the latter percentage being equivalent to about two thousand pounds per acre-foot.

### Destruction of Humus.

Humus, like all other organic substances, may be destroyed by dry decay through exposure to hot dry air, either in the immediate surface of the soil or in the portion that is stirred by the plow or cultivator. The loss each year is imperceptible and the effect is seen only after many years of cultivation, except in soils naturally weak in humus, when there is a decrease in productiveness and a tendency to form a hard crust on the surface. In Minnesota* it was found that cultivation of wheat for eight years caused a loss of 17,000 pounds of humus and 1,700 pounds of nitrogen per acre. The crop itself used 350 pounds of the nitrogen, thus leaving 1,350 as the loss due to destruction of the humus by cultivation. It was also found that summer-fallow was more destructive of humus and its nitrogen than was continuous cultivation in grain; the loss in two years by summer-fallow was 600 pounds of nitrogen or twice the amount used for two crops of wheat.

### Humus in California Soils.

In California the general practice of continuous grain-growing on the same land, and especially of summer-fallow, for the past many years has resulted in the lessening of the humus content and its nitrogen in the soil by the cultivation required, and as a consequence the yields of grain have fallen off year by year. An instance of this destruction by cultivation was shown in the examination of the soil of the University Farm at Davis, which had been under continuous grain culture for thirty or more years when purchased by the University. The humus percentage of the first foot was found to be .79, with 4.55 per cent of nitrogen. The humus in the virgin soil just outside of the wheat field was 1.25 per cent and its nitrogen 5.90 per cent. This difference of .46 per cent of humus and 1.35 per cent of nitrogen, between the cultivated and uncultivated soils, indicates a loss of more than one third of the nitrogen, caused by wheat culture. This is equivalent to 18,400 pounds of humus and 1,520 pounds of nitrogen per acre. The effect of this loss of humus and its nitrogen has been seen in the falling off in productiveness and in an increased tendency of the soil to form a thin surface crust, and in other ways to so affect the physical properties of the soil as to interfere with the proper development and functions of the grain roots. The soil becomes lighter in color, more compact, poorly aerated and less retentive of moisture. Percolation of water from rainfall or irrigation is slower and evaporation from the surface more rapid, the soil becoming dry to quite a depth.

This loss of humus and its nitrogen in the surface soil is a necessary

*Bulletin No. 70, Minn. Expt. Station.

evil everywhere, for the soil must be plowed and cultivated to maintain proper conditions for high productiveness, and it is a loss more quickly felt, of course, in soils where the amount of humus is low. After many years of cultivation it will be felt in soils having a good supply of humus, but which exists only in the upper six or eight inches. It should not be felt in decreased productiveness of the crop for fifty or one hundred years in soils having a good humus content through a depth of several feet; and it would not be if proper attention were paid to the maintenance of good tilth, aeration and water supply, and to the encouragement of the penetration of the roots to the deep source of supply. Had California grain-growers treated their soils rightly during the past years and kept them in good tilth to a depth of 10 or 12 inches, the high yield of 40 to 50 bushels of wheat in early years (*e. g.*, on the sandy lands of Stanislaus County in 1879) would have been maintained to the present time, for the grain roots would have found ample supplies of nitrogen in the humus which we show in this bulletin exists to a depth of many feet. The loss of humus has, however, been severely felt in the soils of many parts of the State, not only because there was naturally but a small amount in the surface soil, but largely because of the methods of cultivation and treatment the soil has received. In fact, this shallow plowing seems to be the source of most of the trouble that comes to the farm and orchard in a country so blessed with deep and rich soils.

### Humus in the Surface Foot.

The results of the soil examinations have brought out the fact that, while the supply of *potash* is as a rule very large and should not need replenishment by fertilizers for decades, and that *phosphoric acid* is generally fair in amount, except in lands that have been in wheat culture for many years, the percentage of *humus* in all surface soils except tule swamps is quite low and has required a system of green manuring to bring the land back into the best condition.

*Cursory Examinations.* Because of the time required to make an accurate analysis of each soil and especially as the question was chiefly as to the sufficiency or insufficiency of potash, phosphoric acid, lime, and humus, we adopted at the beginning a scale of tests by which approximate results could be reached very quickly. The results for humus were graded into "good" for 1 per cent and above, "fair" for 0.7 to 1 per cent and "poor" for less than .7 per cent in the surface soil. It may be of interest to give a summary of the results obtained from 1893 to 1908, the time when, because of pressure of more important work, these examinations were brought to a close.

The following table presents the results, by agricultural regions, from 1,456 soils in which the humus was determined. The percentages of "good" for those above 1 per cent, "fair" from .75 to 1 per cent, and

"poor" for less than .75 per cent of humus are given for each region, and also for the entire State.

| | Number of soils examined | Good humus | Fair humus | Poor humus |
|---|---|---|---|---|
| | | Per cent | Per cent | Per cent |
| Sacramento Valley | 211 | 55 | 18 | 27 |
| San Joaquin Valley | 434 | 24 | 24 | 52 |
| Foothills of Sierra Nevada | 66 | 59 | 12 | 29 |
| Coast Range valleys | 398 | 64 | 19 | 17 |
| Southern California | 347 | 43 | 23 | 34 |
| Average | 1,456 | 46 | 21 | 33 |

It will be seen from the above that more than one half of the soils of the Sacramento, Foothill, and Coast Range regions that were sent for examination by farmers of those regions had as much as one per cent of humus, though for the State at large, only 46 per cent of the 1,456 soils had that amount.

*Regular Analyses of Carefully Selected Soils.* From time to time, since the establishment of the station, nearly five hundred complete analyses have been made of soils chosen to represent the different agricultural regions and conditions in the State, and among the determinations was that of the exact amount of humus in the surface soil. The method of humus determination used was what is known as the Grandeau Method as modified by Professor Hilgard. The results therefore more nearly represent actual average conditions in the soils of California. The following table shows the average percentages of humus in the soils of the several regions.

TABLE SHOWING PERCENTAGES OF HUMUS IN SURFACE SOILS.

| Regions | Number of soils examined for humus | Average percentage of humus | Percentage of soils having more than 1 per cent of humus |
|---|---|---|---|
| Tules and Meadows | 14 | 3.62 | all |
| Coast Range valleys | 91 | 1.69 | 67 |
| Sierra Foothills | 46 | 1.23 | 41 |
| Sacramento Valley | 29 | 1.14 | 50 |
| Southern California | 61 | .94 | 28 |
| San Joaquin Valley | 67 | .79 | 29 |
| Desert plains and Lava-bed valleys | 23 | .51 | 0 |
| General average for State | 331 | 1.25 | 40 |

The general average of humus in the 331 surface soils taken from different parts of California, and supposed to fairly represent all of the agricultural regions, is 1.25 per cent. If, however, the tule marshes and the meadow lands are omitted from the calculation, then we find that the general humus percentage is 1.15. This is almost the identical humus percentage of the average of 306 soils of the arid region (1.13)

given by Professor Hilgard in his book on Soils, page 377, and embracing soils from Idaho, Arizona, Oregon, and California.

It is a peculiar fact that of the 331 soils examined only forty per cent had more than one per cent of humus in the first foot, thus showing the need for replenishment by the turning under and humification of green manure crops for a series of years.

## DISTRIBUTION OF HUMUS DOWNWARD FOR MANY FEET IN CALIFORNIA SOILS.

A very marked characteristic of the soils of California is their great depth, as exemplified in the uniformity of color through a depth of several feet, their good texture affording easy penetration of plant roots often to depths of twenty and even sixty feet below the surface; abundant food available for plant use throughout these depths, an absence of any well defined subsoil except at a depth of several feet below the surface, the absence of any compact clay substratum differing from the surface foot, and the presence of humus to as much as ten or more feet. In each of these particulars the soils of this State differ from those of the humid states east of the Rocky Mountains, and because of this the methods of culture are different, and in the applications of fertilizers to the soil it is only with difficulty that they can be made to reach the feeding roots of plants.

These facts are soon realized by farmers from the East who come to the farms of California, and find that the eastern methods of cultivation will not give the best results, and must be changed to those found to be more successful. There are several striking facts regarding the humus itself in the soils of California that deserve mention and which distinguish them from the soils of the humid region of the eastern states, one of which has but recently been brought out in the examinations that are being made of the many typical twelve-foot columns from the chief agricultural divisions of the State. These facts are: *First*, the small amount of humus in the first foot of all soils, in comparison with three or more times as much in eastern soils; *second*, the distribution of the humus downward to depths of twelve and more feet in upland soils, the total of which is greater than that of the eastern soils; and *third*, the rather higher percentage of humus nitrogen in the upper feet and the distribution of the humus nitrogen throughout the twelve feet, thus giving the soils of the arid region a higher total of humus-nitrogen content than is found in the humid soils.

*Bacterial Activity in the Soil.* Another highly important advantage possessed by California in her soils is the fact recently brought out by Prof. C. B. Lipman of this station in his paper on the Distribution and Activities of Bacteria in Soils of the Arid Region*: "that soils of the arid region at all depths studied show ammonifying powers, which are, however, generally most vigorous in the first six or eight feet. In one case ammonification was noted in soil from a depth of fifteen feet, or adjoining the watertable * * * As for nitrification my data present again features of striking interest. They go to prove that nitrate

*Univ. of California Publications, Agricultural Sciences, Vol. I, No. 1.

formation, like ammonification, goes on at much greater depths in soils of the arid than in soils of the humid region * * * That nitrification is found commonly down to a depth of five or six feet in soils of the arid region. In one case a soil from an eight-foot depth showed a vigorous nitrifying power."

Professor Lipman's observations greatly emphasize the importance of having the roots of the various crops utilize the food supplies at their command at depth of many feet; for not only is there a nitrogen supply, but our investigations on the soil columns show that the amount of available phosphoric acid and of potash is large at depths of twelve and more feet.

*Leveling of Lands.* The existence of humus and an abundance of available plant food at depths of many feet in our soils is well and practically demonstrated by the fact that when lands are leveled and hogwallows (except in an alkali country) filled up by cutting down the hillocks of several feet height, the exposed undersoil is fully as productive and as quickly capable of producing good crops as the original surface soil. This leveling is very generally and successfully practiced in California, and especially in the reddish hogwallow lands of the eastern side of the San Joaquin Valley, before planting orchard trees. The rock-like hardpan in the bottom of the hogwallows at a depth of a few feet is broken up by a small charge of dynamite to afford good drainage, and the hillocks cut down by plowing and scraping their soils into the natural depressions. There is no unproductive or raw clay substratum similar to that of humid climates to be cut into and exposed, and which must remain for many months before being sufficiently acted upon by weathering agencies to yield even a growth of grass.

*Obtaining Soil Columns.* In 1883 we were asked by the California Commission to furnish a few typical soils of the State for the state exhibit at the St. Louis Exposition, and it was decided to make this feature of depth a prominent one by securing soil columns of about twelve feet in depth, each foot in the column being shown in its place in wide bottles placed one above the other and properly labeled. Eighteen of these columns were taken by us from different sections of the State and placed on exhibition. These proved to be so attractive to visitors by illustrating the nature and depth of California soils and their examination proved of such importance in establishing the presence of available plant food and of humus at great depths that we have added to the collection, and there are now one hundred and ten columns which

NOTE.—Much difficulty was experienced at the outset in securing soils to a depth of twelve feet without great expenditure of time and money, as large samples of a foot each were necessary for representatives in the soil column and for analyses. A posthole auger (made and patented by Messrs. Iwan Bros., of South Bend, Indiana) was at last found and proved to be admirably suited to the purpose; it cuts rapidly on bottom and sides and holds the soil well. Fitted with extension pipes of three foot lengths which are easily removable, the auger is made to reach any depth except when coarse gravel or hardpan is encountered.

represent the most important of the soils of the many agricultural regions of the State. These have been arranged in vertical positions in the soil museum of Budd Hall and are being examined as rapidly as possible from a chemical, physical, and biological standpoint. The results will be presented in a special report.

### Distribution of Humus in Soil Columns from Each Agricultural Region.

The agricultural regions of the State comprise the Sacramento and San Joaquin valleys, forming together the central Great Valley, the Foothills lying on the western slope of the Sierra Nevada, the many Coast Range valleys and low hills among the mountain ranges along the western side of the State, the Southern California valleys and the low hills, the Desert Plain which is being brought under cultivation by the development and use of irrigation water, and the Northeastern Lava-bed valleys. A large portion of the State is too mountainous and rugged for tillage and is partly timbered with forests of redwood, pine, and other trees suitable for lumber. The redwood forests form a region of the Coast Range of mountains.

As the object of this investigation was chiefly to ascertain the extent to which humus was found in the lower depths of the soils, the soil columns were only taken from those regions whose soils are many feet in depth. The number of columns obtained was 110 from thirty-seven counties, each column intended to represent a characteristic type of land in its particular region. There are of course very many small valleys and minor soil regions that have not been included in this investigation, some of which may be taken up later and reported when the results of the chemical and physical examination of these soil columns are given to the press. The analyses of the first foot of the soils of many of these regions have already been published in the reports of this station. It is believed that the results presented in this investigation represent very well the humus conditions that prevail in the soils in general throughout the State.

The humus and nitrogen determinations given in the following pages were made successively by Messrs. F. E. Johnson, M. E. Holter, and F. H. Wilson.

### Soil Columns of the Sacramento Valley.

The valley of the Sacramento River, lying between the two great mountain ranges—Sierra Nevada on the east and Coast Range on the west—and which unite on the north, covers an area of 6,200 square miles. The valley is widest on the south where it unites with the San Joaquin Valley. Within its area are four or five general and highly distinct soil regions, or types, each of which is represented by one or more soil columns in our collection, or eighteen in all.

*Alluvial Lands.* These border the Sacramento River and are timbered with sycamore, white oak, and ash. The soil is a dark loam with little or no change to the depth of twelve feet, as shown in the soil columns, and even deeper. Three columns were taken from the following localities: Near Cottonwood, Shasta County, by W. S. Guilford; Glenn post office, in Glenn County, east of Willows; and near Perkins, Sacramento County, by Professor George Roberts, now of the Kentucky Agricultural College. To these was added a column of the alluvium of Chico Creek, taken from the Bidwell place, at Chico, Butte County.

*Clay Loams of the Valley.* These reach south from near Red Bluff and occupy the central part of the Sacramento Valley. As typical of this class of soils, seven columns were obtained from the following localities: Three miles west of Tehama, Tehama County; Willows, Glenn County; J. W. Walton's place a few miles south of Yuba City, Sutter County; Woodland, Yolo County; the University Farm, Davis, Yolo County; Live Oak, Sutter County, and from near Elmira, Solano County. In each case a depth of 12 feet was reached except at Live Oak, where at 9 feet the presence of water prevented a deeper sampling.

*Black Adobe Clay Soils.* There are several regions of these black clays within the eastern, western, and southern parts of the Sacramento Valley. One of these reaches from southwest of Yuba City northward, passing west of Gridley and beyond Biggs. A column was taken from this belt, a few miles southwest of Yuba City, the surface soil of which contained 39 per cent of clay. Below this upper foot the color changed from black to gray. Another column was taken by F. E. Johnson from near Biggs. This contained 50 per cent of clay in its upper foot and the black color changed to gray below the third foot.

A region of black clay lies three miles east of Willows, Glenn County, whose surface foot contains 47.46 per cent clay, and the black color extends through five feet. A column of this was taken to the depth of twelve feet. Another column was taken from a body of intensely clayey and black land lying south of Dixon. It contains 61.75 per cent of clay.

*Red Mesa and "Bedrock Lands."* These form a wide border along the eastern and northern sides of the valley, and are characterized by usually shallow soils underlaid by either heavy compact red clays, or by cemented beds of gravel and grit, forming a hardpan or bedrock at depths of from two to five feet below the surface. Because of the shallowness of these lands, this region is represented by but three columns; one from near Sheridan, Placer County, representing the lands on the eastern side of the valley; another from the bluff of Oak Creek, southwest from Red Bluff, and one half mile west of the Corning road; and still another taken by F. E. Johnson near Acampo, San Joaquin County.

HUMUS AND HUMUS-NITROGEN IN SOILS OF THE SACRAMENTO VALLEY.

| | Per cent humus | | | | | Per cent humus-nitrogen in soil | |
|---|---|---|---|---|---|---|---|
| | First foot | Upper 3 feet | | Twelve feet | | First foot | Upper 3 feet |
| | | Average per foot | Sum of per cents | Average per foot | Sum of per cents | | |
| Alluvial soils | 1.47 | .92 | 1.47 | .67 | 7.50 | .08 | .06 |
| Black clay adobe | 1.16 | .73 | 2.20 | .31 | 3.62 | .06 | .04 |
| Gray clay loams | .95 | .77 | 2.39 | .42 | 5.02 | .05 | .05 |
| Red mesa lands | .47 | .30 | .90 | .15 | 1.43 | .03 | .02 |

It would naturally be supposed that because of their deep color the black clay adobe soils would contain more humus than any other soil, but the above results show that such is not the case, for the alluvial soils are richer, and even the gray loams have nearly as much as the black adobe in the first foot and are a little richer in the rest of the column. The color of a soil, then, is no certain guide as to the relative amount of humus it contains.

Among the individual columns the richest of the alluvial group are those from Glenn and Chico, the former in the upper three feet and the latter in the entire column; there is .52 per cent in the twelfth foot of the Chico column.

The richest of the clay loam group is that from Davis, the average in the upper three feet being 1.16 per cent and an average of .755 for the entire column; the twelfth foot contains .69 per cent. The columns from Tehama, Waltons, and Willows are next in their respective percentages, Waltons being the richest in the upper three feet.

The black adobe east of Willows is the richest of the four that form the composite column, and contains an average of 1.27 per cent in the upper three feet.

### Soil Columns of the San Joaquin Valley.

San Joaquin Valley, with an area of one thousand square miles, possesses many large and distinct soil types or regions, each of which is represented in our soil collection in columns of ten or twelve feet each.

Twenty-four localities in eight counties were selected from which to obtain columns of soil as nearly typical as possible of each region, and fifteen of the columns were taken to depths of ten or twelve feet, the others being limited in depth either by hardpan, coarse gravel or other obstruction which prevented the penetration of the soil auger; sometimes the water table at depths of less than ten feet produced such mushy conditions in the soil as to prevent its being removed by the auger.

*Rich Alluvial Lands and Tule Marshes.* The rivers of the San Joaquin Valley are usually bordered by narrow bottom lands, the Merced and Kings rivers being exceptions where they enter the valley plains. A column of eight feet depth was taken by F. E. Johnson from the lands of Kings River near Kings River post office, and is the only representative of such lands from this valley. The surface soils of other streams have, however, been examined from time to time and their humus content ascertained.

The *tule marshes* cover a very large region at the junction of the San Joaquin and Sacramento rivers and are divided up into islands by many sloughs. The soil of these islands is shallow and peaty though rich, and water appears at but a few feet below the surface. There are localities, however, where a deep soil may be found, and from one of these a column of twelve feet was obtained for us by W. W. Mackie of the United States Bureau of Soils. It was taken from a few miles northwest of Stockton, and is an excellent representative of these lands.

*Black Adobe Clay Lands.* A large area of black adobe land occupies an area in San Joaquin County extending from two miles north of Calaveras River south to French Camp slough and from the tules or marshes of San Joaquin River eastward toward the hills, and is timbered with oaks. The character of the soil is shown in a column twelve feet in depth taken three miles southeast of Stockton.

The region continues southward in a narrow belt along the base of the hills into Kern County, being known in Tulare County as "dry bog," because of its tendency to break up into small fragments when dry. It is here underlaid by a reddish clay loam from which it is sometimes separated by a whitish calcareous or siliceous lime and magnesian bed of varying thickness. Two columns of this black clay adobe were secured from near Porterville, one of which appears in the table of analyses.

On the west side of the valley another narrow black adobe belt reaches along the base of the hills from west of Tracy into Merced County on the south. It is represented by a column of ten feet taken three miles west of Tracy.

*Reddish Clay Lands.* A prominent and wide region of lands of this character occupies a large part of the eastern side of the valley; it is narrow on the north in San Joaquin, Stanislaus, Merced, and Madera counties, and on the south in Tulare and Kern, but quite wide in Fresno County. It is the southern extension of the belt of "bedrock" lands of the Sacramento Valley. It is largely characterized by a rocky hardpan of cemented gravel and grit, with thicknesses of an inch to as much as twelve inches, and even more, and occurring at depths of from two to six or eight feet below the surface; when it occurs near the surface, the

hardpan, because of its irregular bedding, gives rise to a rolling or hog-wallow feature. An excellent soil underlies the hardpan, however, and when the latter is broken up by dynamite good results in tree growth are usually obtained.

Columns of this land were obtained from a few miles east of Fresno; from the Kearney Park; from Lindsay in Tulare County; and from two miles southwest of Farmington, San Joaquin County, sent by H. Mueller.

*Delta Plains of Kings and Kern Rivers.* There are two tracts of this class of lowlands which are made of fine sediment brought down from the Sierra Nevada; the Coast Range on the west contributing little or nothing to these deltas, as its streams mainly flow westward to the Pacific.

The Mussel Slough region bordering Tulare Lake received its sediment from Kings, Kaweah, and Tule rivers and covers a very large area. It is timbered with oaks, and the nature of its soils are shown in columns twelve feet deep, taken respectively from near Corcoran and Armona.

The Kern River delta further south, with an area of about 290 square miles, is also timbered with oaks. It is represented in the soil collection by a column taken three miles southwest of Bakersfield. Water was reached in the seventh foot.

*Gray Sandy Loams and Sandy Soils.* The greater part of the San Joaquin Valley is covered with gray sandy and sandy loam soils on the east side of the valley and with gray clay loams on the west side. On the east side, the slope of the valley to the central trough is wider than on the west, and the numerous and rapidly flowing streams have brought from the Sierra much sand and gravel, which comprises from 85 to 95 per cent of the composition of the gray soils. Notwithstanding their very sandy nature these lands are usually deep and very highly productive under adequate rainfall or irrigation. Calcareous hardpans are found in some localities in irregular sheets and at various depths, but their injurious effects can be obviated in orchards by blasting; a good soil underlies them. Columns of these lands were obtained from Modesto, Stanislaus County; from three miles west of Tulare; and from a few miles north of Exeter, both in Tulare County; and from near Livingston, Merced County.

*Gray Clay Loam Lands.* The lands on the west side of the valley are quite level and contain more clay than those of the east side. There are but few streams on the west side, and these have their source but a short distance within the Coast Range, whose drainage is almost entirely westward. These west-side lands, therefore, must have been deposited from the waters coming from the Sierra Nevada after they had dropped

their sands and gravels on the east and become more quiet; thus permitting the fine silt and clay to settle. The soils contain from 15 to 24 per cent of clay. Columns were obtained from south of Tracy, San Joaquin County; from four miles west of Los Baños, Merced County; and from Val Verde, two miles west of Mendota, Fresno County.

*Gray Alkali Lands.* Some of the gray loams contain large amounts of alkali salts in small areas usually, the salts consisting of varying proportions of carbonate, sulfate and chlorid of sodium and frequently causing serious farming difficulties. Columns of soil were taken from three localities which contained very large amounts of alkali. These are as follows: from the "white ash" lands southwest of Fresno; from the old experiment station tract near Tulare; and from Miramonte, Kern County.

The "white ash" soil, so called because of its fine light, ashy and silty nature, was taken from near a vineyard in Central Colony, several miles southwest of Fresno, and is the representative of a large region lying on the north side of Kings River and reaching to within two miles of Fresno and eastward toward the foothills of the Sierra. The soils are rich and have been largely devoted to grape growing. The water table was reached at a depth of four feet, the soil assuming a white color, and, below the sixth foot, losing all traces of humus.

The Tulare column was obtained from the old experiment station tract in a spot where all vegetation had been killed by the alkali salts.

The column from Miramonte, fifteen miles west of Wasco, represents what seems to be a belt of low lands, or what was once a slough connecting Tulare Lake with those southward and in which the alkali of the lakes had accumulated to great depths. The alkali consists chiefly of the sulfates and chlorids, Glauber and common salt, and in this column it was distributed at the rate of one half of one per cent per foot, or a total approximating 233,000 pounds for the twelve feet. No vegetation other than scattering alkali weeds was seen.

*Tulare Lake Bed.* A large part of the bed of Tulare Lake was a few years ago quite dry, and samples of the soil to many feet depth were sent to us for examination as to their alkali content. The humus percentage of each foot was also determined.

The table below gives in a concise form the relative percentages of humus and nitrogen in the eight soil types of the San Joaquin Valley, and from it we can make comparisons more easily than from a study of the soil columns themselves. The types are placed in the order of highest to lowest composite averages of humus in the first foot, and this almost represents the succession in the combined upper three feet and the entire column respectively.

HUMUS AND HUMUS-NITROGEN IN SOILS OF THE SAN JOAQUIN VALLEY.

| | Per cent humus | | | | | Per cent humus-nitrogen in soil | |
|---|---|---|---|---|---|---|---|
| | First foot | Upper 3 feet | | Column, 12 feet | | First foot | Upper 3 feet average |
| | | Average per foot | Sum of per cents | Average per foot | Sum of per cents | | |
| Tule marshes | 14.10 | 16.68 | 50.05 | 6.81 | 81.75 | .83 | .88 |
| River alluvium | 1.29 | .83 | 2.50 | .30 | 3.67 | .06 | .04 |
| Black clays | 1.09 | .82 | 2.48 | .25 | 3.02 | .06 | .04 |
| Red lands | .95 | .76 | 2.28 | .32 | 3.89 | .06 | .05 |
| Delta plains | .81 | .49 | 1.49 | .22 | 2.59 | .04 | .03 |
| Gray sandy loams | .66 | .47 | 1.40 | .25 | 3.05 | .04 | .03 |
| Gray clay loams | .86 | .68 | 2.04 | .34 | 4.12 | .06 | .04 |
| Alkali lands | .34 | .30 | .90 | .12 | 1.47 | .03 | .02 |
| Tulare Lake bed | .18 | .14 | .42 | .10 | 1.20 | .01 | .01 |

There are large differences in the amount of humus in the several groups, as is to be expected from soils of such extremely different characters, the highest percentage being in the tule marshes and the lowest in the strong alkali lands and in the Tulare Lake bed.

The surface soils of the valley are not rich in humus as a rule, and this is well shown in these tables. Even the black clays and loams, which because of their color would be supposed to contain high percentages, were found to have but little more than one per cent, and in some instances less than that. Similarly, the alluvial and delta soils of Kings and Kern counties are very low in humus. The tule marshes in the region of Stockton are naturally rich, because of the great amount of vegetable matter, such as roots and leaves, that have accumulated in them, and we find as much as 14 per cent of humus in the first foot and 19 in the second. In but eight of the individual columns (omitting the Stockton tule) is there as much as one per cent in the surface foot, the highest being found in the reddish lands of Farmington, and the lowest, .18 per cent, in the soil of Tulare Lake bed.

In the upper three feet the amounts of humus in the alluvium, the black clays and the red lands, are nearly the same; and they are about equally rich in nitrogen; but in the column of twelve feet depth the black clays fall behind the other two, and the gray clay loams of the western side of the valley take first place in humus content.

The river alluvial lands then are richest in humus in the first foot and upper three feet, but the gray clay loams contain the highest percentage in the entire column of twelve feet. The individual soil richest in nitrogen, except the marshes, is that from Farmington, which has .14 per cent, equivalent to more than 5,000 pounds per acre foot. The average through all of the soils is low.

The alkali lands, including the Tulare Lake bed, contain very little humus and the soils are very poor in humus nitrogen, though they often have quite a percentage of nitrates. The very large amount of alkali

salts they contain evidently has so retarded or prevented the growth of surface plants as to cut off the supply of humus-forming material.

## HUMUS IN THE SOILS OF THE FOOTHILLS OF THE SIERRA NEVADA.

The lower foothills of the Sierra Nevada, rising from the Sacramento and San Joaquin Valley plains to an elevation of 2,500 feet above sea level. form an important fruit-bearing region of the State. The soils are mainly derived from the slates and granites, and while they are deep in the valleys they are usually shallow on the hills, though the upturned slates permit of the deep penetration of plant roots between the layers to moisture and food.

Columns of these soils were taken from the valley lands near Palermo, Butte County; from the rolling hills of the old experiment station tract east of Jackson, Amador County; and from a bluff near Newcastle, Placer County, which afforded a deeper sampling than did the other two localities. The result of the examination of the soils from each of the localities is given in the table below, in a depth of twelve feet for the soil from Newcastle and of eight feet each for the others.

HUMUS AND HUMUS-NITROGEN IN RED SOILS OF FOOTHILLS OF SIERRA NEVADA.

| | Per cent humus | | | | | Per cent humus-nitrogen in soil | |
|---|---|---|---|---|---|---|---|
| | | Upper 3 feet | | Column, 12 feet | | | |
| | First foot | Average per foot | Sum of per cents | Average per foot | Sum of per cents | First foot | Upper 3 feet |
| Palermo | .96 | .51 | 1.52 | .29 | 2.06 | .06 | .02 |
| Newcastle | 1.35 | 1.26 | 3.77 | .47 | 5.64 | .10 | .05 |
| Jackson | 1.07 | .65 | 1.96 | .33 | 2.86 | .05 | .02 |

The red clay soils of Jackson and Palermo are quite similar in the amount of humus found in the first foot, but the former is richer below that depth. The clay is quite compact and close, and this seems to have prevented the development of roots to the depth permitted by the looser gravelly granitic soil of Newcastle, in which there is more humus. The general average of humus in the first foot of these three soils is 1.12 per cent; that of 31 soils of the foothills previously examined is 1.05, though it is found to be higher in the valleys farther up in the mountains, in the regions of Auburn, Grass Valley, Nevada City, and Placerville.

The nitrogen in the respective soils is below the amount it should be, except in the upper three feet of the Newcastle column, which contains an average of .10 per cent, or approximately 4,000 pounds per acre foot.

## SOIL COLUMNS OF THE COAST RANGE VALLEYS.

The Coast Range of mountains reaching from the Oregon state line south to the Mexican border has but few agricultural possibilities outside of the many valleys enclosed between the mountain ridges. The country north of Mendocino County is especially rugged, and the valleys are few, but southward there are many valleys that present splendid agricultural attractions, and we have endeavored to have the soils of the largest and most important ones represented in the columns of this series. Of course, it must be understood that in each valley there are a number of soil-variations and graduations from the hills to the lower valley center, and that the column has been selected to represent the best and most extensive of these, the object being to ascertain to what depth and in what percentage the humus reaches under favorable conditions. Fifteen valleys in nine counties have their soils represented in the series of columns, and in the accompanying tables are arranged in order of occurrence from north to south.

We may conveniently follow the usual subdivision of the Coast Range counties and arrange the table into the counties *north* of the bay, embracing seven soil columns; the *bay region* itself, embracing the country east and west of the bay as far south as San Jose, represented by eight soil columns; and the counties *south* of the bay as far as Santa Barbara, represented by nine soil columns.

### North of the Bay Region.

The valleys represented in this section of the Coast Range are Russian River, Santa Rosa, Los Guillocos, Sonoma, Napa, and Vaca: there are other important though much smaller ones east and west of these and in the counties farther north.

*Russian River Valley.* The soil columns from this valley were taken from the alluvial lands of the hop fields belonging to T. Boone Miller six miles south of Healdsburg, and from the red hills three miles southwest of Healdsburg, Sonoma County.

*Santa Rosa Valley.* The western part of the valley has a heavy adobe soil, which is not as largely in cultivation as is the more loamy land of the eastern and middle part. A column of twelve feet depth was taken from the creek alluvium on the Vrooman orchard east of Santa Rosa.

*Los Guillocos Valley.* This valley is not very wide nor long, and it opens northward into Santa Rosa Valley. Its soil is a reddish loam and is represented by a column taken a short distance southeast of Kenwood, Sonoma County.

*Sonoma Valley.* The valley opens southward to the bay and is largely covered by marsh lands, but the northern part is higher and

comprises better lands. A black adobe clay seems to be the prevailing soil, and a column of this was taken near the village of El Verano.

*Napa Valley.* The soil is chiefly loamy in nature, interspersed with some adobe belts on either side. A column of the former was obtained near Yountville, Napa County, to a depth of twelve feet.

*Vaca Valley.* This valley is situated among the foothills on the west side of the Sacramento Valley, into which it opens, and is noted for its early fruits. The soil is chiefly a reddish loam, as shown in the column obtained near Vacaville.

### East of the Bay Region.

*Alameda Plains.* The bay shore rises gently eastward to the foot of the Contra Costa hills, a distance of about two miles. On this slope the soil is largely of an adobe clay nature. The city of Berkeley is situated on this slope, the University of California being at the foot of the hills. A column of the clay adobe was taken from the Economic Garden on the University Campus. Southward from Berkeley and Oakland the slope widens into a plain traversed by streams from the Coast Range bordered by wide bands of a more loamy soil, and upon it are found extensive farms and several towns. A column of the loam was taken from the land of Mrs. Sanborn south of Niles, and another from the Meek place near Hayward.

Eastward across the Contra Costa hills several narrow valleys connect the large and fertile Livermore Valley with the bay shore on the north, and representative columns of soil were taken from three of these.

*Ignacio Valley.* Along Walnut Creek there is a narrow belt of black clay loam soil bordered by land more adobe-like in nature which extends to the low mesa and hills. The higher land on the mesa and bordering it in the valley has a stiff and black adobe clay soil about three feet in depth and underlaid by a whitish material. The column was obtained from the place of Professor F. T. Bioletti, one mile north of Walnut Creek, Contra Costa County.

*San Ramon Valley.* This valley is a continuation southward of Walnut Creek Valley, but wider and with more extensive black adobe soils, a column of which was obtained in the vicinity of San Ramon post office, Contra Costa County.

*Livermore Valley.* The soil of the valley plain is a loam while that of the low hills of the west and south is reddish and gravelly. A column was taken to a depth of ten feet from the plain in the Santa Rita region, Alameda County.

### South of the Bay Region.

*Santa Clara Valley.* This valley, reaching from the bay of San Francisco southward for 70 miles into San Benito County, has a variety of soils. Around the bay back from the salt marshes is a black clay adobe, a column of which was taken from the Morse Seed Farm near Santa Clara. The soil contained 4.43 per cent of humus, which is the highest we have found in any of the soils of the State except the marsh lands. South of San José the lands are more loamy in character and are represented by a column taken from near Gilroy, by F. E. Johnson. The valley west of San José has a soil more sandy in nature and more or less gravelly, on which are located extensive orchards. A column of this soil, seemingly representative of this land, was taken from the El Quito ranch, south of Saratoga.

*Pajaro Valley.* The soil of the valley proper is a dark loam, while along the river are adobe clays and clay loams, the latter being devoted to sugar beet culture. The valley loam is alone represented in the soil column series. It was taken from the apple-growing section on the Watsonville side of the valley. Another column of soil was taken from Watsonville heights one mile northwest of the town. At eight feet depth a mass of decomposed granite was reached. Both columns were taken by F. E. Johnson.

*Salinas Valley.* The lower or northern part of the valley for about 50 miles is from 8 to 12 miles wide, but to southward the valley is very narrow. Two classes of soil are represented in the series. A column of 15 feet from the sandy loam lands of the west side of the Salinas River was taken at Fort Romie near Soledad; and a column of the black adobe lands around King City, Monterey County, was kindly sent by Mr. R. L. Adams, formerly of the Spreckels Sugar Beet Company.

*Arroyo Grande Valley.* The soil of this narrow but important valley is of a dark and heavy clay-loam nature to the depth of twelve feet and more. Two columns were obtained by F. E. Johnson, one near the town of Arroyo Grande, the other from the farm of the Routzahn Seed Company a few miles to the westward, the only apparent difference being a darker color in the surface foot of the seed-farm soil.

*Santa Maria Valley.* The soil is chiefly a sandy loam of a brownish color and very deep. A column was taken by F. E. Johnson near the sugar beet fields west of the town of Santa Maria.

*Lompoc Valley.* Three chief classes of soils occupy the valley: adobe near the hills, sandy alluvium near Santa Ynez River, and an intermediate type of clay loam between them. The Burpee seed-farm is situated on the clay loam lands, and a column of soil was taken there to a depth of 12 feet, when water was reached.

HUMUS AND HUMUS-NITROGEN IN VALLEY LANDS OF THE COAST RANGE REGION.

*North of the Bay Region.*

| | Per cent humus | | | | | Per cent humus-nitrogen in soil | |
|---|---|---|---|---|---|---|---|
| | First foot | Upper 3 feet | | Column, 12 feet | | First foot | Upper 3 feet, average per foot |
| | | Average per foot | Sum of per cents | Average per foot | Sum of per cents | | |
| Russian River Valley | 1.76 | 1.55 | 4.64 | 1.01 | 12.18 | .08 | .06 |
| Santa Rosa Valley | 1.95 | 1.50 | 4.51 | .92 | 11.10 | .09 | .08 |
| Los Guillocos Valley* | 2.25 | 1.74 | 5.21 | .92 | 6.45 | .13 | .10 |
| Sonoma Valley | 2.14 | 1.71 | 5.12 | .84 | 10.05 | .11 | .05 |
| Napa Valley | 2.61 | 1.98 | 5.94 | .95 | 11.38 | .11 | .08 |
| Vaca Valley | 1.97 | 1.22 | 3.67 | .71 | 8.53 | .13 | .08 |

*7 feet deep.

*East of Bay Region.*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Alameda Plains | 1.68 | 1.39 | 4.27 | .64 | 9.79 | .09 | .08 |
| Livermore Valley | .64 | .67 | 2.02 | .45 | 4.46 | .06 | .04 |
| San Ramon Valley | 1.23 | 1.19 | 3.59 | .57 | 6.90 | .07 | .05 |
| Ignacio Valley | 1.42 | 1.34 | 4.02 | .80 | 9.68 | .08 | .07 |

*South of Bay Region.*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Santa Clara Valley | 3.97 | 2.22 | 6.65 | 1.03 | 11.05 | .10 | .07 |
| Pajaro Valley | 1.38 | 1.18 | 3.56 | .74 | 6.64 | .09 | .06 |
| Salinas Valley | 1.11 | .83 | 2.50 | .55 | 6.66 | .05 | .04 |
| Arroyo Grande Valley | 3.14 | 2.15 | 6.47 | 1.33 | 16.60 | .16 | .11 |
| Santa Maria Valley | 1.44 | 1.13 | 3.39 | .46 | 5.57 | .11 | .07 |
| Lompoc Valley | 2.50 | 1.86 | 5.57 | 1.09 | 13.03 | .13 | .09 |

The soils of the valleys of the Coast Range are remarkably high in their humus content when compared with the other soils of the arid region. The general average of the State is 1.25 per cent in the surface soil, while that for these coast valleys is 1.94 per cent. But especially does this difference appear when we note the many individual soils in which 1 per cent of humus is found at depths of four, five and even seven feet. In nearly all of the columns there is a decrease downward, indicating that the humification was of plant roots rather than of vegetable matter deposited from overflow as the land was being built up.

A comparison of the average amounts of humus in the soils of the three divisions shows that the lands of the valleys north and south of the bay region are richer than those on the east, both in the surface foot, the upper three feet, and in the depth of twelve feet. Santa Clara and Arroyo Grande valleys have the highest percentages in the first and the upper three feet, while Arroyo Grande and Lompoc valleys stand first as regards the entire depth of twelve feet.

It is interesting to note that Russian River Valley on the north and these three valleys on the south have averages of more than one per cent for the entire depth of twelve feet, the only instances of this among all of the soils of the State thus far examined excepting the tule marshes.

It is also to be noted that all of the valleys of this group of sixteen,

except Livermore and Salinas, have averages of more than one per cent of humus in the upper three feet, and that Santa Clara and Arroyo Grande have more than two per cent each.

The percentage of nitrogen in the first foot is highest in the valley of Arroyo Grande, .16 per cent or approximately 6,400 pounds per acre. Los Guillocos, Vaca and Lompoc valleys have .13 per cent each. Sonoma, Napa and Santa Maria, .11 per cent each, and Santa Clara has .10 per cent, while all others have less. Among the individual soils, Gilroy has .15 per cent and Berkeley .14 per cent.

In the upper three feet, Arroyo Grande and Guillocos valleys are the richest in nitrogen, the approximate amount being 12,000 pounds per acre in the three feet.

### SOIL COLUMNS OF THE SOUTHERN CALIFORNIA REGION.

The region known as Southern California embraces that part of the State lying south of the Sierra Madre Mountains, and includes a number of large and fertile valleys and plains.

*Saticoy Plain.* The long and broad slope in Ventura County, reaching from the mountains southward to the sea shore and noted for its lima bean culture, is represented by two soil columns, one taken by J. B. Neff from near Mound Schoolhouse a few miles east of Ventura, and the other from the orange grove of Mr. N. B. Blanchard, at Santa Paula.

*Santa Clara River Delta.* This comprises a broad region of gray alluvial land, and contains more or less alkali salts in places. Water is usually found at a depth of 8 or 10 feet below the surface. The delta is noted for its sugar-beet culture. A column was taken near Springville by J. B. Neff to a depth of 8 feet, where water was reached.

*Pleasant Valley Hill Slope.* This column was taken from the sandy slope of the hills north of the Southern Pacific Railroad station at Camarillo, on the property of the Citrus Farms Company.

*San Fernando Valley.* The valley of San Fernando lies north of Los Angeles and includes about 200 square miles. Much of the valley on the east is covered by débris of cobblestones, gravel sand washed from the canyons on the northeast, but the rest of the valley has sandy and sandy loam soils, with some heavier clays on the south.

Two columns were obtained by F. E. Johnson: one from the sandy lands about one half mile north of Fernando, representing the "granitic wash land" at the foot of the hills; the other from lowland near the old Mission two miles west of Fernando.

*San Gabriel Valley.* This valley lies east of Los Angeles and reaches from the mountains southward to the alluvial plains. It is watered by the San Gabriel River and bordered on the east by the Puente Hills, and San Antonio débris cone. Its soil is a sandy loam. A column of

soil was taken by F. E. Johnson from the neighborhood of Covina and "represents an average of all of the different soil types." Another column was taken by Johnson from near Monrovia, and represents the heavier type of soil, the greater part of which is sandy and gravelly wash from the hills.

*San Bernardino Valley.* The eastern portion of the valley of Southern California, known as the San Bernardino Valley, is separated from the western by a range of low hills and by the débris cone of the San Antonio Creek, which issues from its valley just above Pomona and supplies most of the water to Chino Creek, which empties into the Santa Ana River. In the past, from time to time portions of the San Antonio flow has been diverted into the San Gabriel.

The valley covers a large area and comprises a large variety of soil types, a few of which are represented by soil columns. The valley slopes toward the south to the Rincon Basin and Santa Ana River, and is bordered by a rim of mesa on the north, east, and south.

*The Valley Plains.* The soils are chiefly of a sandy nature, of excellent depth and good fertility. The lowlands are sometimes highly charged with alkali that has been brought in by drainage from the higher valley. Several types of soil from the plains are represented in the columns.

*Sandy loam soils* of the central part of the valley are shown in a column from the former University of California Experiment Station tract, three miles southwest of Ontario, taken by J. W. Mills.

*Highly sandy soils,* apparently accumulated by wind storms blowing in from the mountain passes on the north, lie in the central part of the valley and are extensively planted in grapevines, the roots of which penetrate downward for very many feet. A column of this type of soil was secured at Guasti from the land of the Italian Vineyard Company.

*Alluvial plains* of the Santa Ana River, known as the Victoria Tract, a few miles east of San Bernardino.

The soils of the valley plain are all quite sandy and contain but small amounts of humus and of nitrogen. The tendency to crust over and to form a sandy hardpan or plowsole near the surface is quite usual with these soils. A succession of good green-manure crops grown, turned under deeply, and allowed to humify properly would add much to the value and fertility of these lands.

*Low Lands.* Near the border of Chino Creek there are low-lying lands forming a wide border of "moist lands" which do not need irrigation. Ten acres of these near Chino formerly formed a part of the Experiment Station of Southern California. A column from this was

taken by F. E. Johnson. Another column was taken near Pomona from a marsh spot known as a "cienega." This is a "limited area showing growth of water-loving plants, appearing sporadically in otherwise arid surroundings—usually hillsides or valley margins and occasionally giving rise to flowing springs." (Rept. Cal. Expt. Sta., 1892–1894, page 185.)

*Mesa Lands.* The mesa lands that border the valley are largely of a reddish loam type, interspersed on the north side by deposits of sand and gravel from the hillsides.

The red mesa extends eastward up the Gorgonio Pass to its summit at Banning, where it forms quite a high plateau above Timoteo canyon.

A column of the sandy mesa of the north side was taken in the western part of Highlands to a depth of twelve feet, in which the sandy soil continued to the bottom.

A column representing the red clay mesa was taken near Redlands by F. E. Johnson. The upper five feet were of reddish, sandy loam nature, below which there is a change to a sandy clay and finally to a gritty stratum.

A column from Riverside was taken from Arlington Heights orchard lands on the south, and we were able to reach a depth of eighteen feet with comparative ease.

Another mesa soil column was taken by F. E. Johnson from nearly one mile south of the town of Corona, and is a good representative of the orchard land of that vicinity. A depth of twelve feet was reached with difficulty because of the presence of much gravel.

*Los Angeles Alluvial Plain.* The three rivers, Los Angeles, San Gabriel and Santa Ana, have each brought down from the San Bernardino Mountains large quantities of silt, sand and clay, and formed a large body or region of alluvial lands, known as the Los Angeles Alluvial Plains. Each river preserves its own course through these plains, and has built up its own alluvial plain with its own material independently of the others. We thus find that the soils of the San Gabriel are of a more sandy nature than those of the Santa Ana, probably because of the greater velocity of the river current over a shorter distance. The Santa Ana leaves the mountains east of San Bernardino and flows by a circuitous route along the southern side of the valley and thus has left most of its coarse material behind and deposited chiefly clays and silts in the alluvial plain.

*The San Gabriel Plain* is represented by three columns. One was taken from the place of Doctor Twombly, south of Fullerton, to a depth of ten feet; another from the place of J. B. Neff, near Anaheim; while the third column was taken a mile south of Compton.

*The Santa Ana Alluvial Plain* is represented by two columns taken by F. E. Johnson. One of these from two miles south of Santa Ana, to represent a considerable area of heavy black adobe. The other from Irvine, six miles southeast of Santa Ana, represents a lighter clay loam soil. Both of these columns are from the south side of Santa Ana River.

## INTERIOR VALLEYS.

The immediate coast line is bordered by a wide mesa which extends south to the state line, interrupted by characteristic deep and narrow valleys or occasional streams. The valley of San Diego River is wide and affords much land for culture purposes. The mesa reaches eastward in considerable width to the foot of the higher rolling hills, which rise still higher into the San Jacinto Mountains. Numerous valleys small and large lie among these hills, whose soils are rich and productive.

*Fallbrook Mesa.* The hills or mesa are for the most part somewhat rolling and capable of cultivation whenever the soil is of sufficient depth and extent. Fallbrook affords an example of these cultivable hills, and a column of the soil was taken from the hillside vineyard of Loma Ranch, south of the town. The red clay loam soil was of varying thickness and underlaid by a mass of disintegrated granite.

*Perris Valley* lies southeast of Riverside at the western foot of the San Jacinto Mountains. It is about 10 miles long and 6 miles wide, and has a variety of soils as described by Professor Hilgard in the annual report of this experiment station for 1894–95. The heavier soil from the center of the valley about a mile east of the town of Perris was selected and a column taken by F. E. Johnson.

*The Valley of Escondido* is large and productive, lying at the edge of the mountain. Its soil is a loam. A column was taken to a depth of twelve feet by F. E. Johnson in the vineyard of C. C. Katzenburger on the north side of the valley.

*El Cajon Valley* lies among the high mountains 29 miles east of San Diego and has an area of 6 by 4 miles. The land is a reddish sandy loam and is very productive. A column twelve feet in depth was taken from near the crossroads by F. E. Johnson.

HUMUS AND HUMUS-NITROGEN IN SOILS OF SOUTHERN CALIFORNIA.

| | Per cent humus | | | | | Per cent humus-nitrogen in soil | |
|---|---|---|---|---|---|---|---|
| | | Upper 3 feet | | Column, 12 feet | | | |
| | First foot | Average per foot | Sum of per cents | Average per foot | Sum of per cents | First foot, per cent | Upper 3 feet, per cent |
| Saticoy Plain | 1.23 | .95 | 2.86 | .52 | 6.90 | .06 | .05 |
| Santa Clara Delta | .96 | .65 | 1.96 | .34 | 2.84 | .07 | .04 |
| Fernando Valley | .90 | .71 | 2.12 | .43 | 5.23 | .04 | .03 |
| Camarillo hillside | .84 | .65 | 1.96 | .30 | 3.66 | .05 | .02 |
| San Bernardino plains | .43 | .41 | 1.22 | .16 | 1.95 | .02 | .02 |
| San Bernardino mesa | .67 | .44 | 1.33 | .28 | 2.75 | .04 | .03 |
| San Bernardino lowlands | 4.28 | 2.59 | 7.79 | 1.20 | 11.63 | .18 | .10 |
| Alluvial plains | 1.16 | .84 | 2.65 | .44 | 5.26 | .07 | .05 |
| Perris Valley | .35 | .59 | 1.77 | .30 | 3.60 | .05 | .03 |
| Fallbrook | .55 | .37 | 1.12 | .15 | 1.78 | .03 | .02 |
| Escondido Valley | .47 | .29 | .89 | .13 | 1.56 | .03 | .02 |
| El Cajon Valley | .93 | .50 | 1.50 | .18 | 2.10 | .05 | .02 |

The nitrogen percentages are nearly all too low and indicate the great need of good green-manuring for a number of years to build up the upper three feet of soil into a high fertility. This is needed more than phosphate fertilization.

There are but six of the twenty-five soils whose surface foot contains more than one per cent of humus; there are but five others that have more than .75 per cent, and there are five whose humus falls even below .50 per cent.

The lands represented by these columns from Southern California are under such continuous cultivation that the surface foot is hardly a proper unit of comparison; a depth of three feet would be more nearly correct, for in that is usually found the mass of feeding roots, and no disturbing irregular conditions exist. The general average of the total amount in the three upper feet (sum of per cents) of the columns (omitting that of the Pomona Arroyo), is 1.98, or an average of .66 per cent per foot.

The Santa Ana adobe and Chino moist land have each above 4.50 per cent in the upper 3 feet and Mound has 3.11 per cent, but all others fall below the latter. Six of the columns have more than two per cent each, while on the other hand three have each a sum of less than one per cent in the three feet or an average of but .25 per cent per foot.

The humus in these soils is with a few exceptions not especially rich in nitrogen, and, as a consequence, the soil is but meagerly supplied with that element.

## SOIL COLUMNS OF THE NORTHEASTERN LAVA-BED REGION.

The lava-bed region, comprising a large portion of the northeastern part of the State, reaches north from the Sierra Nevada Mountains into Oregon, and is a region of lava-bed plateaus and hills interspersed with occasional valleys that are capable of cultivation to a large extent in grain and alfalfa.

*Honey Lake Valley.* This valley with its large lake lies between the foot of the Sierra and the lava hills on the north, and has an elevation of about 4,000 feet above sea level. It is divided into the Honey Lake Valley proper and the East Side Valley, which extends from the Lake eastward into the desert region.

Honey Lake occupies the lower part of the valley and is bordered on all sides by lands which are being brought under cultivation in grain and alfalfa, except on the east, which is of a more sandy and alkali nature. A column of soil was taken to a depth of ten feet from near Standish on the north side of the valley, humus being found only in the upper five feet; a large and luxuriant growth of alfalfa covered the adjoining fields.

Another column of soil taken by Professor G. W. Shaw from a strong alkali tract bordering the lake on the east side near Amedee, contained but little humus.

*East Honey Lake Valley.* This desert-like region comprises that portion of Honey Lake Valley in Lassen County that reaches eastward from the lake into Nevada at an elevation of about 100 feet more than the lands around the lake, and lies between hills of lava débris. The width is about 15 miles, but increases to much more toward the state line. The soil of the plain is for the most part quite free from alkali salts, which only appear here and there on the surface; but toward the state line at lower levels the alkali is more abundant. On the north side of this plain the soil is quite level and sandy, with a reddish sandy subsoil.

A wide belt of alluvial land borders Skedaddle Creek with a depth of three or four feet near the creek. Beneath this there is, as shown in a well on the place of A. L. Spoon at Stacy Station, two feet of sand, twenty feet of a calcareous clay, underlaid in turn by blue sand and clay. A column of soil was taken for examination from this place to a depth of twelve feet. Its upper foot contained .64 per cent of humus, the second foot 1.26 per cent and below this the humus percentage decreased to .20 per cent in the twelfth foot.

It is interesting to note here that a well on the place of Mr. Caudle, north of Stacy, exposed three feet of a reddish soil, three feet of sand, seven feet of boulders and fifteen feet of white calcareous clay; below

this appeared blue clay to a depth of 320 feet from the surface, water being reached at that depth.

In the center of the valley the surface of the land is in low ridges, the sandy soil being blown into hillocks; the soil is underlaid by a very compact gray silty soil to ten feet; then beneath that is ten feet of a fine sand, followed by ten feet of a coarse sand in which water is struck in wells. Beneath this lies a blue clay of fifty feet or more thickness. A column of soil was taken in this land to twelve feet depth from near the place of Dr. B. B. Bolton four miles north of Calneva. In this the humus occurred in each foot of the column, but in very small amounts. On the south of the Western Pacific Railroad at Calneva to the mountains the soil is coarsely sandy.

*Madeline Plains.* Passing north from Honey Lake Valley across hills covered with beds of lava we come to the Madeline Plains, which occupy a large and almost level basin (probably once an inland lake) at an elevation of 5,200 feet above sea level. Its area is approximately 150 square miles, very irregular in outline, and bordered on all sides by lava hills. Its soil is a dark and very compact clay underlaid at three or more feet by a light colored marl of a hardpan nature and upwards of 75 feet in thickness, as shown in well borings. A column of this soil four feet in depth was obtained from the plain to westward of the place of W. C. Brockman. Previous analyses of other samples show fair amounts of phosphoric acid. Grass and grain are said to do well on this plain. The surface foot was found to contain .52 per cent of humus, and the second foot .60 per cent, but below this the clay was almost free from it. The soil contains about .04 per cent of humus nitrogen.

*Pit River Valley.* Pit River, with its source at the foot of the Warner range of mountains, passes through a number of valleys as it flows westward into the Sacramento River. The town of Alturas is located in one of these valleys at the junction of the two forks of the river. The soil of the valley is chiefly meadowland, with water at a few feet and partly grown in tules, but affording large alfalfa tracts. A column of six feet was taken from an alfalfa field near the town. The valley is bordered by lava-bed mesas and hills. Goose Lake Valley to northward and reaching into Oregon has a similar meadowland soil reaching from the lake eastward to the foot of the mountains, where the disintegrated débris afford some higher land on which orchards are planted.

*Klamath Lake Marshes.* A column from the tule marshes of Klamath Lake, Butte Valley, Siskiyou County, was obtained for us by Mr. L. S. Robinson for examination.

*Surprise Valley.* Eastward from Alturas, the Warner range of mountains separates the Pit River Valley from Surprise Valley with its three large lakes. The land of this valley on the east is strongly charged with alkali salts, but on the west the broad slope from the mountains to the lake presents excellent agricultural possibilities, the production of alfalfa seed being quite a prominent industry. A column of soil ten feet deep (to water) was obtained from the valley two miles south of Cedarville, and another column of four feet from the meadowland that forms a broad border to the lake and in which water was struck at four feet.

HUMUS AND HUMUS-NITROGEN IN SOILS OF THE LAVA-BED REGION.

| | Per cent humus | | | | | Per cent humus-nitrogen in soil | |
|---|---|---|---|---|---|---|---|
| | | Upper 3 feet | | Column, 12 feet | | | |
| | First foot | Average per foot | Sum of per cents | Average per foot | Sum of per cents | First foot | Upper 3 feet |
| Honey Lake Valley | .54 | .45 | 1.35 | .23 | 2.73 | .03 | .02 |
| Pit River Valley | 3.05 | 1.84 | 5.51 | 1.20 | 7.23 | .06 | .06 |
| Surprise Valley | 4.29 | 2.25 | 6.75 | 1.10 | 10.98 | .05 | .04 |
| Surprise Valley meadows | 2.71 | 1.89 | 5.67 | | | .09 | .09 |
| Klamath marsh | 3.75 | 3.32 | 9.97 | 1.81 | 14.52 | .34 | .29 |

The soils from the Honey Lake Valley contain very little humus even in the surface foot, but it is found throughout the entire column except at Standish, and it is very poor in nitrogen. The humus is apparently derived from the débris and roots of the sagebrush and alkali weeds that grow on the plain.

With an abundant water supply and the turning under and humification of some good legume crop there is no reason why the lands of East Honey Lake Valley, at their elevation of 4,000 feet above sea level, should not produce crops suitable to that altitude as well as the lands of Imperial Valley which are below sea level, though climatic conditions naturally would control the kind of crops grown.

The column taken from Standish on the north side of the lake and from an alfalfa field is surprisingly low in humus below the surface foot. The underlying whitish limy loam seems to have restricted the development of plant roots to the upper four feet. The humus is also poor in nitrogen and was probably derived from the meager roots of sage and alkali weeds. A soil previously taken from the Susanville Meadows had only .33 per cent of humus, and another from two miles west of Amedee had but .29 per cent. The Pit River Valley clay soil is under cultivation in alfalfa, and the amount of humus is large, though very poor in nitrogen. On the other hand, the Klamath column is from tule marsh lands, containing a larger proportion of decaying vegetable matter, and consequently is quite rich in humus in each of the

upper four feet. The humus is especially rich in nitrogen, and, as a consequence, the soil is also enormously rich in it through its upper four feet. The fifth and sixth feet are largely made up of diatomaceous earth in which the humus has suddenly diminished to less than one per cent, while beneath this there is but a trace of humus.

The surface soil of the Cedarville loam is surpassed in its percentage of humus (4.29 per cent) by only the black clay of Santa Clara and the marsh lands among all of the soils of the State thus far examined, and it ranks as fifth with regard to the amount in the three upper feet. The percentage throughout the entire column of ten feet is quite high. This high humus content may be due to the alfalfa crops that have been produced for seed on this soil for a number of years past, as a soil from another locality near Cedarville examined ten years ago contained but 1.56 per cent in the surface foot. The humus is, however, remarkably weak in nitrogen (1.14 per cent) if such was its origin.

The meadow soil lying at a lower level is very similar to that of Alturas in its humus content.

### SOIL COLUMNS OF THE "DESERT" PLAINS.

The term "desert" is here applied to the extent of country with scant rainfall and having a vegetation of sagebrush and largely devoid of grasses; a country whose soils are usually rich in the mineral elements of plant food and which are remarkable for their fertility when properly cultivated and abundant irrigation water is used. The reason for this fertility lies partly in the fact that the humus, though small in amount, is with its nitrogen well distributed throughout a depth of twelve feet and more, in a soil whose sandy or silty texture permits deep rooting of plants.

Some of the valleys have with irrigation been brought under cultivation and settlement, and from these a few soil columns were secured.

*Imperial Valley.* This newly settled part of the State, the bed of Salton basin, which on drying up became a desert until reclaimed by irrigation, largely lies below the level of the sea. Its soils, derived from the sediment of the Colorado River, have a peculiar light pinkish tint, and are made up of alternating strata of silt and a very plastic impervious clay of varying thickness. When this clay forms the surface soil, the difficulties of cultivation and irrigation are very great, but when the clay lies at a depth of several feet below the surface of silty soil, the reverse is true. This peculiar type of land is represented in the series by two columns of soil, one from the vicinity of Imperial and the other from near El Centro; these and that from Coachella were taken by F. E. Johnson.

*Coachella Valley.* A column was obtained from the vicinity of

Coachella and represents the higher and more sandy lands that bordered the old Salton Lake of the Imperial country.

*Mojave River Mesa.* This mesa or plain is formed by accumulation of granitic débris from the Sierra Madre Mountains on the south and reaches far out toward Barstow, San Bernardino County. This débris is coarse and quite compact, and in the neighborhood of Victorville is said to have a thickness of 35 feet or more. It is here overlaid by about three feet of a gray sandy soil, also quite compact and supporting a sparse vegetation of weeds. A column of eleven feet was obtained three miles west of Victorville. The soil was found to contain but .13 per cent of humus in the surface foot, .14 per cent in the second, .10 per cent in the third, and .08 per cent in the coarse sand of the fourth foot. There were but traces of nitrogen in the humus.

*Owens River Valley.* The agricultural lands of this valley lie chiefly on the western side of Owens River and are formed from the débris of the adjoining Sierra Nevada. A column of soil was secured through the kindness of Mr. W. K. Winterhalter of San Francisco.

HUMUS AND HUMUS-NITROGEN IN SOILS OF THE "DESERT" PLAINS.

| | Per cent humus | | | | | Per cent humus-nitrogen in soil | |
|---|---|---|---|---|---|---|---|
| | First foot | Upper 3 feet | | Column, 12 feet | | First foot | Upper 3 feet, average |
| | | Average per foot | Sum of per cents | Average per foot | Sum of per cents | | |
| Imperial Valley | .28 | .24 | .72 | .22 | 2.68 | .02 | .01 |
| Coachella Valley | .32 | .23 | .68 | .15 | 1.86 | .01 | .01 |
| Mojave River Plains | .13 | .12 | .37 | .04 | .45 | trace | trace |
| Owens Valley | .31 | .24 | .73 | .13 | 1.56 | .01 | .01 |

It was to be anticipated that the soils of what are known as the desert plains of the eastern and southeastern part of the State would be very poor in humus because of their very sandy nature together with small rainfall, extreme summer heat and scant vegetation, but it was a surprise to find that humus occurred at depths of twelve or more feet below the surface. The soil poorest in humus is that from the mesa plain just west of Victorville, in which plant roots were found to a depth of three feet only, the underlying material being too compact for root penetration. It, however, supported a growth of yucca and desert weeds, and on the same mesa with presumably the same soil though deeper, near Hesperia there are a few orchards. A glance at the table shows that there is nearly the same percentage of humus in the first foot of each of the columns and very little difference in the total amount in the upper three feet of the columns.

The very unequal distribution in the El Centro column is somewhat surprising, for it might readily be supposed that the small amount in

the surface foot would indicate that there was scarcely any in the lower depths; whereas we find higher percentages in the fourth, fifth, eighth, and tenth foot respectively than in either of the upper three feet. It is interesting to note that there is more in the lower half of the column than in the upper. The humus of these columns is not quite as rich in nitrogen as that of the soils from other parts of the State, and that of the Bishop column is extremely low. The nitrogen of the soil is not more than .01 per cent or about 400 pounds per acre foot.

### Individual Soil Columns Having the Highest Humus Content.

In looking over the 109 columns of soil taken from the various agricultural regions of the State we find that eighteen have each more than two per cent of humus in the surface foot, and thirty-two others have more than one per cent, the remaining fifty-nine having less than that. We also find that nine of the columns have each an everage of more than two per cent of humus in each of the upper three feet, and twenty-five others have an average of more than one per cent, all others falling below the one per cent. In the distribution of the humus through the entire twelve feet of the columns there are ten which give an average of more than one per cent for each foot, and twenty-five others whose average is above one half of one per cent.

In the following table we have placed the names of the twenty localities which have as much as 1.95 per cent in the surface foot, and the twenty which rank highest in averages of the upper three feet and in the entire column of ten or twelve feet.

SOIL COLUMNS HAVING THE HIGHEST HUMUS PERCENTAGES.

| In first foot | | Average of upper 3 feet | | Average of entire column of 10 or 12 feet | |
|---|---|---|---|---|---|
| Stockton tule | 14.10 | Stockton tule | 16.68 | Stockton tule | 6.81 |
| Pomona cienega | 6.23 | Pomona cienega | 3.67 | Arroyo Grande | 1.39 |
| Santa Clara adobe | 4.43 | Santa Clara adobe | 3.63 | Santa Clara (10 feet) | 1.33 |
| Cedarville | 4.29 | Klamath marsh | 3.32 | Pomona cienega | 1.28 |
| Arroyo Grande Seed Farm | 3.78 | Cedarville | 2.25 | Arroyo Grande Seed Farm | 1.27 |
| Klamath marsh | 3.75 | Gilroy | 2.23 | Gilroy | 1.14 |
| Alturas | 3.05 | Arroyo Grande | 2.16 | Cedarville (10 feet) | 1.10 |
| Gilroy | 2.76 | Arroyo Grande Seed Farm | 2.01 | Lompoc Seed Farm | 1.09 |
| Cedarville meadows | 2.71 | Berkeley adobe | 2.01 | Berkeley | 1.04 |
| Yountville | 2.64 | Yountville | 1.98 | Russian River | 1.01 |
| Lompoc Seed Farm | 2.50 | Cedarville Meadows | 1.89 | Yountville | .95 |
| Arroyo Grande | 2.50 | Lompoc Seed Farm | 1.86 | Santa Rosa | .92 |
| Santa Ana adobe | 2.42 | Alturas | 1.84 | El Verano (10 feet) | .84 |
| Chino moist land | 2.31 | Kenwood | 1.74 | Walnut Creek | .80 |
| Kenwood | 2.25 | El Verano adobe | 1.71 | Hayward | .77 |
| El Verano adobe | 2.14 | Farmington | 1.65 | Davis University Farm | .75 |
| Berkeley adobe | 2.13 | Santa Ana adobe | 1.63 | Watsonville | .74 |
| Farmington | 2.04 | Russian River | 1.55 | Chico | .73 |
| Vacaville | 1.97 | Chino | 1.52 | Vacaville | .71 |
| Santa Rosa | 1.95 | Glenn | 1.51 | Glenn | .69 |

### Composite Columns of Agricultural Regions.

In the following table are given the averages of each of the agricultural regions, embracing all of the 109 columns representing the State at large, taken from thirty-seven counties. The tule marshes of Stockton, Pomona, and Klamath are placed in a column by themselves. In some of the individual columns that form the composite for each region either a depth of twelve feet was not secured or the humus itself was not found to that depth.

COMPOSITE AVERAGES OF AGRICULTURAL REGIONS (PER CENTS).

| | Sacramento Valley | San Joaquin Valley | Coast Range valleys | Southern California | Sierra Nevada foothills | N. E. lava-beds valleys | "Desert" plains | Tule marshes |
|---|---|---|---|---|---|---|---|---|
| | 18 columns | 23 columns | 24 columns | 25 columns | 3 columns | 8 columns | 5 columns | 3 columns |
| 1 foot | 1.04 | .80 | 1.94 | .88 | 1.12 | 1.55 | .26 | 8.04 |
| 2 feet | .75 | .51 | 1.47 | .65 | .71 | .92 | .19 | 8.59 |
| 3 feet | .58 | .37 | 1.13 | .45 | .57 | .48 | .17 | 7.05 |
| 4 feet | .45 | .25 | .93 | .37 | .39 | .40 | .25 | 5.52 |
| 5 feet | .36 | .23 | .77 | .31 | .18 | .21 | .18 | 2.65 |
| 6 feet | .32 | .17 | .67 | .27 | .14 | .18 | .13 | 1.45 |
| 7 feet | .23 | .14 | .59 | .25 | .18 | .13 | .13 | .78 |
| 8 feet | .19 | .10 | .49 | .19 | .10 | .12 | .14 | 1.64 |
| 9 feet | .18 | .18 | .41 | .16 | ---- | .11 | .12 | .68 |
| 10 feet | .17 | .06 | .39 | .16 | ---- | .09 | .13 | .30 |
| 11 feet | .16 | .06 | .27 | .13 | ---- | .03 | .15 | .21 |
| 12 feet | .15 | .04 | .32 | .11 | ---- | .03 | .13 | .29 |
| *In 12 Feet.* | | | | | | | | |
| Sum of per cents | 4.58 | 2.91 | 9.38 | 3.93 | 3.93 | 4.25 | 1.96 | 37.20 |
| Nitrogen in humus | 5.45 | 6.53 | 5.15 | 5.54 | 5.64 | 3.69 | 4.69 | 5.63 |
| Nitrogen in soil | .03 | .02 | .04 | .02 | .03 | .03 | .01 | .20 |
| *In Upper 3 Feet; Range of Most Annual Plant Roots.* | | | | | | | | |
| Sum of per cents | 2.37 | 1.68 | 4.54 | 1.98 | 2.40 | 2.95 | .62 | 24.68 |
| Nitrogen in humus | 5.79 | 6.27 | 5.13 | 5.74 | 5.40 | 3.79 | 4.97 | 5.75 |
| Nitrogen in soil | .04 | .04 | .07 | .03 | .05 | .05 | .01 | .44 |
| *In Surface Foot.* | | | | | | | | |
| Nitrogen in humus | 5.68 | 6.08 | 5.43 | 6.50 | 5.93 | 3.53 | 5.03 | 6.35 |
| Nitrogen in soil | .05 | .05 | .10 | .05 | .07 | .05 | .02 | .47 |

On glancing at the table, attention is first called to the depth of twelve feet to which humus reaches in all of the columns except that of the Sierra Nevada foothills, the lava-bed meadows and the tule marshes where, because of the underlying country rock on the one hand and of water on the other, the depths are limited to eight, ten and seven feet respectively. In some of the columns the amount of humus is so high in the twelfth foot, especially in that of the valleys of the Coast Range, as to leave no doubt of its being found at a greater depth had the examination been made. In fact, the column of Fort Romie was

carried through fifteen feet, and .41 per cent of humus with 6.83 per cent of nitrogen was found in the lowest foot.

The next point of interest is the small amount of humus in the first foot of each of the columns excepting those of the meadow lands and the tule marshes. This is especially noticeable in the composite of the San Joaquin Valley and in that of the "Desert" plains. The general average for all of the columns excluding the marshes is 1.16 per cent.

Another point of special interest is the gradual diminution of humus percentage downward in each of the composite columns, with an occasional slight increase, as is seen in the eleventh foot of the Sacramento Valley and the twelfth foot of the Coast Range valleys. This decrease indicates smaller amounts of humus-forming vegetable material, presumably the roots of plants, in each successive foot downwards, the main mass of the root systems being in the upper three or four feet.

*Average of Three Upper Feet.* A depth of one foot does not in reality represent a soil in this State which is at least three feet deep, and it would not be correct or fair to the cultural possibilities of the land to draw conclusions from the humus of the first foot alone. It is very true that its presence to the extent of several per cent near the surface is of special importance in maintaining proper physical textural conditions for aeration, avoidance of crusts and easy penetration of water, but it is of as great importance that there should be several per cent of humus in each of the upper several feet, for in arid regions it is below the first foot and away from hot and dry top soil that the feeding roots of plants prefer to carry on their activities, and it is in the upper three feet that the main mass of fine feeding roots is usually located, and where they must secure the needed plant food supplied by the humus. This not only protects the roots, but gives to them a far greater feeding area, which is enlarged with the extension of the humus downward. The summations for three feet are given at the foot of the table.

*Sacramento Valley.* The Sacramento Valley represented in the above table by a composite column of eighteen individual columns is not only richer than the San Joaquin Valley in the first foot in humus, but in every foot of the entire column to a depth of twelve feet. One half of the total amount is held in the upper three feet. Its first foot contains a little less than that of the Southern California column, but in the upper three feet and in the entire column there is more. The percentage in the first foot is too small and clearly shows the need of its being increased by a system of growing and turning under of green crops. With this to encourage the growth of the young grain and trees the lower portion of the column will afford humus nitrogen and other plant food for the roots that find their way downward to twelve or more feet, as was the case with wheat and barley roots on the University farm at

Davis. In the latter soil the humus of the first foot was only .85 per cent and that of the second foot 1.49 per cent; the ordinary yield had been but from 12 to 14 bushels of wheat per acre before the University bought the property. By proper method of treatment and without irrigation or fertilization the agronomist in charge, Prof. G. W. Shaw, secured a yield of 40.4 bushels of wheat per acre as an average of three years, during which time the average for the State was but 14.5 bushels. (Bulletin No. 211.)

The humus-nitrogen content of the upper three feet of the Sacramento composite column is 5.79 per cent of the humus and .04 of the soil. This is approximately 1,600 pounds of nitrogen per acre for each foot in depth.

*San Joaquin Valley.* The composite of 23 columns from the San Joaquin Valley show humus percentages much below those of other regions both in the surface foot (.80 per cent) and in each foot of the entire column. The sum of 2.91 per cent, if contained in the upper foot of the three feet would be a fair amount, though much below that of other regions. The low percentages may be due in part to the presence of alkali salts in some of the soils examined, also to a more arid climate of far less rainfall than in other regions, and to a less luxuriant vegetation upon the decay of whose roots the amount of humus is dependent.

Although this humus percentage is so low in the upper part of the soil, yet a proper system of deep plowing to break up any tendency to form a plowsole and to make the soil loose and of good texture for a downward development of the crop roots, which may thus secure the benefits of the humus, would tend to greatly increase the grain yields of the valley. This was shown in the experiments of Prof. G. W. Shaw at Ceres and Tulare,* where, during a period of three years by this method the average yield of wheat was 35 and 33 bushels respectively, while the average wheat yield for the State was 14.5 bushels per acre. No irrigation or fertilization was used in his experiments.

The humus-nitrogen of the upper three feet of the composite column is 6.27 per cent of the humus, which is higher than in any of the other composite columns in the table. In the soil itself, however, there is but an average of .04 per cent or 1,600 pounds per acre foot.

*Sierra Nevada Foothills.* The composite of three columns from the Sierra Nevada Foothills shows more humus in the first foot than in that of the Sacramento Valley or Southern California. That of the second foot is, however, somewhat less and there is a greater decrease in the lower part of the column, the sum being but 3.39 per cent in the eight feet. More than one half of the humus is held in the upper three feet.

*Bulletin No. 211.

The humus-nitrogen in the upper three feet of the composite column is 5.40 per cent of the humus or .05 per cent in each foot of the soil, and is equivalent to 2,000 pounds for each acre foot in the three feet.

*Coast Range Valleys.* The composite column of the 24 soils of the valleys of the Coast Range shows a general average of nearly two per cent of humus in the surface foot, and thus is far above each of the other columns, except the marshes and meadow lands. Not only that, but it is the only column of the uplands which has more than one per cent in the soils immediately below the first foot. The percentage of humus in each of the succeeding feet throughout the twelve feet is also higher than in any other of the composite columns; the twelfth foot has nearly one half of one per cent and the sum of the entire column is 9.38 per cent. The humus is not as rich in nitrogen as that of the San Joaquin or Southern California, and the amount of organic nitrogen in the soil is below the .05 per cent regarded as necessary for fertility.

*Southern California.* The soils of the valleys of Southern California represented by the composite of twenty-five columns have about the same humus content in the first foot, and in the upper three feet, as was found in similar parts of the columns from the Sacramento Valley and the Foothills; but is far behind that of the Coast Range valleys. The humus is well distributed downward to twelve feet, and, as with the Sacramento Valley soils, affords an excellent and large feeding area for plant roots. Every encouragement should be given crops to take advantage of this by sending their roots deep into this fertile soil mass. The upper three feet contain a little less than one half of the total humus.

The humus of the first foot is too low for the maintenance of good physical condition and careful attention should, as a rule, be given to the turning under of green crops and the humification of the same.

The humus in the upper three feet contains 5.74 per cent of nitrogen, but there is only .03 per cent of organic nitrogen in the soil: this is equivalent to about 1,200 pounds per acre foot, which, under the influence of bacteria, gradually becomes available for plants.

*"Desert" Plains.* The "Desert" lands represented by a composite of five columns from the valleys of Imperial, Coachella, Owens River and Mojave River are very low in humus in their upper several feet, as is to be expected from the meagerness of the natural humus-forming vegetation. One half of the humus is held in the upper five feet instead of in three as is the case with other regions. The presence of so much humus in the twelfth foot is a matter of some surprise, for the lands seem usually quite deficient in natural moisture other than hygroscopic for hundreds of feet in depth. The amount of humus in the twelfth foot is one half that of the first foot.

The humus of the upper three feet contains but 4.97 per cent of nitro-

gen, and there is but .01 per cent of organic nitrogen in the soil: this is equivalent to about four hundred pounds per acre foot, which is very low.

*Lava-bed Valleys.* The valley lands of the lava-bed region of the northeastern part of the State have in the composite of eight columns a high percentage of humus, not only in the first foot but in the second. This is natural, as the soils are moist from underlying water and there is a strong vegetation whose roots penetrate deeply. The total sum of humus percentages in the 12 feet is 4.25 per cent, the upper three feet holding more than one half of it. The humus is poorer in nitrogen than in any of the regions except the desert, the average in the upper three feet being 3.79 per cent, or .05 per cent in the soil.

*Tule Marshes.* The tule marshes near Stockton and Klamath, and the Pomona cienega have extremely high humus percentages in each of the four upper feet, and the humus is also quite high through the column of eight feet, all derived from the large amount of decaying tule roots. The humus nitrogen of the upper three feet is, however, only 5.75 per cent in the humus or .44 per cent in the soil; the latter is much higher than found in any of the columns.

### Nitrogen in the Humus.

Nearly one thousand determinations of nitrogen were made in this investigation, and of these there were but 64 where the humus was found to contain more than 10 per cent of nitrogen; fourteen of these had from 15 to 20 per cent and but five had more than 20 per cent. The latter percentage was found in the eighth foot of the Berkeley adobe, the fourth foot of Watsonville Heights loam, the sixth foot of the Kenwood loam, the sixth foot of Santa Paula loam, and the fifth foot of the Fullerton loam.

The general average for all of the soils, including the marsh lands, is 5.92 per cent for the first foot, 5.60 per cent for the upper three feet and 5.57 per cent for the entire depth of twelve feet.

The humus of the surface foot of the composite of Southern California soils is richer in nitrogen than that of any of the other regions though nearly equaled by that of the tule marshes. That of the lava-bed valleys is poorer in nitrogen than any others.

The humus of the upper three feet of the composite column of the San Joaquin Valley is much the richest in nitrogen, and that of the lava-beds again the poorest. Four of the eight columns fall below the general average for the State. The same is true for the averages of the twelve foot columns.

The differences in the percentages of nitrogen in the humus of the upper three feet and of the total columns are not very great, except in the valleys of the Coast Range, where it is considerably smaller; and in

the lava beds and "Desert" plains where there is a very material falling-off.

### Organic Nitrogen in the Soil.

It is well to remark here that .10 per cent of nitrogen in the upper foot of a humid soil is regarded as an ample supply for fertility, while in the arid region with its deeper soil, deeper humus and deeper root penetration, one half that amount, or .05 per cent in each of the three upper feet is considered sufficient for many years, because the roots are in a larger feeding area than in the humid region, and bacterial activity is greater and deeper. This percentage would mean 2,000 pounds of nitrogen per acre in each foot.

The marsh or tule soils of the State have very high amounts of nitrogen, as shown in the Stockton tule .83 per cent, Klamath tule .34 per cent and the Pomona cienega .25 per cent, and is probably due to their wet, soggy condition and lack of aeration. This nitrogen is, however, less available than that of the dry uplands, hence a comparison can not be made. The surface soils that are richest in nitrogen are, the two soils from the Arroyo Grande Valley, including the Routzahn Seed Farm with their .16 per cent of nitrogen each, Gilroy with .15 per cent, Berkeley and Farmington each with .14 per cent, Burpee Seed Farm of Lompoc, Vaca Valley, and Kenwood each with .13 per cent, and El Verano, Santa Maria, Chico, Yountville, and Chino each with .11 per cent. Newcastle soil has .10 per cent, while all others have less.

Nine of the soils have but .01 per cent of humus-nitrogen in the first foot, seven have but .02, forty-six or nearly half of the columns have less than .05 per cent, and hence are much below the desirable percentage of nitrogen. The average of the first foot of all of the columns, excepting the marshes, is about .05 per cent.

Some of the upland soils are quite rich in organic nitrogen in the *upper three feet,* the true soil mass of the arid region. The adobe of Berkeley is the richest with its .13 per cent or approximately 15,000 pounds per acre in a depth of three feet. Eight columns have averages of .10 and upward, viz, the two Arroyo Grande soils, Gilroy, Chico, Farmington, Kenwood, Newcastle, and Cottonwood. Thirty-one colums have averages of from .06 to .10 per cent, all others being below this amount. In other words, we find that more than half of the columns have in their upper three feet less than the .05 per cent of organic nitrogen which is considered necessary for fertility. Many have but little more than traces of the same.

In the entire columns of twelve feet we find that there are eleven upland localities that have averages of as much as .05 per cent. and among these, Berkeley and Arroyo Grande columns stand highest, with averages of .08 per cent or approximately 38,000 pounds of organic nitrogen distributed through the depth of twelve feet.

### Humus-phosphate in the Soil.

When vegetable matter is humified in the soil the phosphoric acid of the plant remains in combination in the humus and that of the soil is also attacked: this humic phosphoric acid is considered as more available to plants than that in the soil. It is probable that all humus contains phosphoric acid, but the amount varies very greatly; in some soils the percentage of humus-phosphate is quite large and adds greatly to the fertility of the soil. In seven of the soil columns of the State the percentage of humus-phosphate in the soil was ascertained through the entire column, but the chief interest lies in the amount contained in the upper three feet, the range of annual plant roots. These results are given in the following table:

| | Phosphoric acid in soil, per cent | In surface foot | | | In upper 3 feet | | |
|---|---|---|---|---|---|---|---|
| | | Humus, per cent | Humic phosphoric acid | | Humus, per cent | Humic phosphoric acid | |
| | | | Per cent | Pounds per acre | | Per cent | Pounds per acre |
| Yuba City clay loam | .18 | 1.27 | .05 | 2,000 | .93 | .04 | 4,800 |
| Chico alluvial soil | .09 | 1.84 | .05 | 2,000 | 1.39 | .04 | 4,800 |
| Stockton adobe clay | .06 | 1.16 | .05 | 2,000 | .81 | .03 | 3,600 |
| Modesto sandy soil | .11 | .37 | .01 | 400 | .28 | .01 | 1,200 |
| Russian River alluvium | .18 | 1.30 | .07 | 2,800 | 1.25 | .08 | 9,600 |
| Santa Clara adobe clay | .12 | 4.43 | .07 | 2,800 | 3.63 | .04 | 4,800 |
| Santa Paula clay loam | .12 | 1.23 | .07 | 2,800 | 1.04 | .06 | 7,200 |

The Russian River alluvium and the Santa Paula clay loam are quite high in their percentages of humic phosphoric acid in the upper three feet; they approximate 3,200 and 2,400 pounds per acre for each foot in depth; an amount amply sufficient to supply the needs of crops for many years. In the upper six feet of soil the Santa Paula, Santa Clara and Russian River columns have each .05 per cent, or approximately 2,000 pounds of immediately available phosphoric acid in each foot.

These high percentages of humic phosphoric acid, with corresponding percentages of humic potash and humic nitrogen throughout these depths of twelve feet are strong reasons why deep-rooting of plants and trees should be encouraged by a deep water supply and deep cultivation or plowing.

### Comparison of Arid and Humid Soils.

A comparison between the soils of the arid and humid regions brings out the very great advantages possessed by the former, and especially by those of California, over the humid, as shown in the first part of this bulletin. But it is especially marked in the amount and distribution of humus in the soils of the respective regions.*

*It has been a rather difficult matter to secure data on humus in the soils east of the Mississippi River for the reason that in their analyses some of the chemists have failed to separate it from the percentage of aggregate "organic matter."

The general average in 280 soils of the humid portion of the United States is 2.63 per cent, and if we add to this the 5.26 per cent in eleven tropical soils of Hawaii, the average is brought to 2.73 per cent or approximately 109,200 pounds per acre.

The average of the 331 California soils and 44 from Idaho, Arizona, and Oregon is 1.28 per cent for the surface foot, or less than one half that of the humid region. For the first foot of the 109 soil columns the average is 1.35 per cent.

But the depth of soil in which most of the plant roots are held and in which the humus color is most pronounced is three feet, and taking this as the true soil of California we find that there is a sum of 3.17 per cent, or an average of 1.06 for each foot; this is equivalent to about 126,800 pounds per acre. To this should be added the percentages of humus found at lower levels of the soil, as shown in the averages of the 109 columns given in the accompanying table, which would bring the total humus to 234,000 pounds in 12 feet.

AVERAGE OF HUMUS IN

| | Arid soils | | Humid soils. 291 soils, general, per cent |
|---|---|---|---|
| | 109 California soil columns, per cent | 342 soils, general, per cent | |
| 1-foot soil | 1.35 | 1.28 | 2.73 |
| 2-foot soil | 1.04 | ? | ? |
| 3-foot soil | .78 | | |
| 4-foot subsoil | .62 | | |
| 5-foot subsoil | .45 | | |
| 6-foot subsoil | .36 | | |
| 7-foot subsoil | .30 | | |
| 8-foot subsoil | .26 | | |
| 9-foot subsoil | .21 | | |
| 10-foot subsoil | .18 | | |
| 11-foot subsoil | .14 | | |
| 12-foot subsoil | .14 | | |
| Sum of per cents in 12 feet | 5.83 | | |
| Sum of per cents in 3 feet | 3.17 | | |
| Nitrogen in humus, 3 feet | 5.60 | | |
| Nitrogen in soil, 3 feet | .05 | | |

The amount of humus then in the average of California soils (3 feet deep) is greater than in those of the humid region; and for the depth of twelve feet it is more than twice as great.

The determinations of humus-nitrogen in the soils of the humid region have been so few and miscellaneous that it is not advisable to deduce from them an average to represent the whole region.

Arid California with her deep soils of well diffused humus and richness in plant food thus possesses very great advantages over the more humid East, where a depth of six to nine inches is very generally accepted as that of a true upland surface soil, containing practically all of the humus and marked by a very sharp change of the black humus color to the gray and yellow subsoil with its inappreciable amount of

humus.* In the sediment lands of the streams and some of the black prairies the humus is of course found at a greater depth.

## CONCLUSIONS.

1. The depth of the soils of California is indefinite because of the presence of humus to and beyond twelve feet below the surface. The upper three feet may, however, properly be called the soil, for within that depth the greater part of the feeding roots of plants are found. The sharply defined change of the black humus color to gray at 6 or 9 inches that marks the depth of humid soils, is present in some of the heavy clay soils in California at the depth of three feet; but for the most part the change in tint is very gradual downward through many feet.

2. The soils of California are richer in humus than has generally been supposed; in their depth of three feet (the soil proper) they contain more than in the humid soils, and in the entire columns of twelve feet or more they have double that of the humid soils.

3. The humus in California soils is usually distributed through depths of twelve or more feet, the highest percentage being in the upper three feet and diminishing downward, as shown in each of the 109 soil columns taken from the several agricultural regions; as much as .41 per cent was found in the fifteenth foot of the Fort Romie column, and .74 per cent in the thirteenth foot of that of Davis and Hayward; water was reached in each case.

4. The surface soils of California have an average of 1.28 per cent of humus, as shown in the analysis of several hundred samples taken from the many agricultural regions of the State. This is not sufficient to maintain good tilth in the soil; but as supplemented by that of many feet below, often affords a fair supply of nitrogen. The upper three feet of soil proper have an average of 1.06 per cent per foot, or a sum of 3.17 per cent.

5. The tule swamps have the highest percentage of humus because of the mass of decaying roots and other vegetable matter, while the deserts have the least.

6. Humification is retarded in close compact adobe clays, and the amount of humus is less than in lighter loam and sandy soils.

7. The valleys of the Coast Range in the western part of the State have higher percentages of humus in their soils than have any of the other agricultural regions, probably because of the greater humidity of the climate of that region, and a denser vegetation.

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*See Hilgard's Soils, page 164, and Agricultural Science, 1892, page 263; King's The Soil, page 29; Hall's Soils, page 45; Minn. Bulletins 30, 41 and 65 contain analyses of 121 subsoils, in only 16 of which is humus reported though found in all of the corresponding surface soils which were taken to depths of nine inches. (Bulletin 30, page 164.)

8. Arid soils have an immense advantage over those of the humid region of the United States because of this distribution of humus and its nitrogen through a depth of many feet; as it gives a greater depth of soil and induces a deeper root penetration for plants and trees into a greater feeding area and where there is more moisture. The wonderful endurance of drought on the part of plants on California soils is due to this.

9. Humus contains nitrogen in combination, the amount depending on the source of the humus. The average percentage in the humus of the first foot of the soil columns is 5.92 per cent; that of each of the upper three feet is 5.60, and a little less for the entire twelve feet in depth. It varies from one to twenty per cent in individual soil layers.

10. The organic nitrogen in the soil derived from the humus and dependent on the amount of the latter, varies from almost nothing in the lower depths of the soil to as much as .13 in the upper three feet. The average for the first foot of the soil columns is .07 per cent; for each of the three upper feet, the range of most annual plant roots, it is .05 per cent. The investigations of Professor Lipman of this station show that nitrifying bacteria are present and active in California soils to a depth of six feet, and ammonifying bacteria are present through a depth of twelve feet; thus making available to plants the nitrogen content of the humus to these depths.

11. The humus of the soils of this State is very generally derived from plant roots, instead of from accumulations of vegetable material at various depths as the soil was being built up; thus showing that these plants have for ages been deep-rooted.

12. The black color of a soil is not always due to a high humus content; many black soils have a smaller percentage of humus than soils of a gray color. In one instance a very black clay soil from the Santa Clara Valley contained no humus, its color being due to the presence of a black mineral.

13. Humus contains soluble mineral plant food in combination, the phosphoric acid being present in the humus of California soils to the extent of from .01 per cent to .08 per cent throughout the entire depth to which humus reaches, though usually greatest in the upper few feet.

14. Humus is sometimes less in the first foot than in the second, because it is gradually destroyed by cultivation and summer-fallowing of the soil; but may be replaced and increased by proper methods of green-manuring, or the turning under and humification of green crops, preferably legumes.

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# THE INTRADERMAL TEST FOR TUBERCULOSIS IN CATTLE AND HOGS

BY

CLARENCE M. HARING

ASSISTED BY

RALPH M. BELL

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## FOREWORD

In all ages, trees and grasses have been the most important products of the soil. The efficient, economic utilization of grass and similar forage, which can be accomplished only by the use of domestic animals, is one of the world's great problems. It is a basic problem in California. Animals are necessary to utilize the grass on its vast ranges, including valleys, foothills, and mountains, and also to utilize one of the most important products of irrigation—alfalfa. The production of butter fat is almost an economic necessity wherever alfalfa is extensively raised. Domestic animals, however, do more than convert into edible form the products of the soil. They help to maintain its fertility: first, by returning to it essential fertilizing ingredients and, second, by permitting a more diversified system of agriculture.

Obviously one of the most important factors in the efficiency of this living machine is its health. If animals when grown are unfit for food, in so far as this occurs it becomes a tax upon every pound of wholesome beef. If the average usefulness of a cow extends only through three periods of lactation, as is claimed to be the fact in some milch dairies, the cost of producing every pound of butter fat and every bottle of milk is thereby increased.

The most disastrous disease among cattle is tuberculosis. It is a menace that no stockman or dairyman can afford to ignore. Its control is a problem that every state must seek to solve as surely as it must endeavor to develop an abundant food supply.

Of the eight thousand head of cattle examined under the direction of the veterinary division of this Station, approximately twenty-five hundred have reacted to the tuberculin test. The loss from this disease in California alone is estimated at over half a million dollars per year. The loss appears to be increasing. Reports of meat inspectors in San Francisco and Los Angeles indicate that the proportion of cattle from certain ranges, which are affected with tuberculosis, has increased from 1 to 5 per cent in five years.

The Agricultural Experiment Station has resolutely set itself to study this problem with all the resources at its command. It is going to be a long, hard road to travel. A thorough study of the conditions under which this insidious disease is spread among domestic animals must be made. Then a sane, rational, comprehensive system of public control must be organized. All evidence points to the fact that it must be on lines not heretofore generally attempted in this country.

Up to the present time the most efficient weapon with which to combat tuberculosis in cattle has been the tuberculin test. A description of the usual method of performing this test was published by this Station in Bulletin No. 199, entitled "Bovine Tuberculosis," which may be obtained free upon application. This method, however, of performing the tuberculin test by injecting the tuberculin subcutaneously has not proved effective in all cases. It cannot be applied satisfactorily to young calves or to wild range cattle, while during the hot season in some of the interior valleys the test has been unsatisfactory even when applied to docile dairy cows. A recent modification of the tuberculin test, called the *intradermal method*, is especially adapted to these conditions. This bulletin deals with the best technic and the proper strength of the tuberculin to be used in this new method, as well as its accuracy as compared with the usual subcutaneous method. The intradermal method is believed to constitute an important step in the control of tuberculosis in both cattle and hogs. However, it should be clearly understood that a method of discovering the disease, which any tuberculin test is, is not, in itself, a method of controlling it. When the proper knowledge has been obtained of the conditions under which the disease spreads, a system of husbandry must be developed which will ensure the maintenance of healthy animals.

THOMAS F. HUNT,
Director.

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## GENERAL CONCLUSIONS REGARDING THE INTRADERMAL METHOD OF TUBERCULIN TESTING CATTLE

The intradermal method of tuberculin testing cattle as first applied by the French investigators Moussu and Mantoux[37] and as used under California conditions by Ward,[50] Baker, Longley[23] and others has many advantages over the usual method. Since the reaction to tuberculin when injected intradermally depends upon a swelling at the point of injection and not on a rise of temperature, it is to be preferred to the subcutaneous under all conditions that are liable to modify the tuberculin temperature curve, such as unusual surroundings, very hot weather, or fatigue from a long journey. It can be satisfactorily applied to young calves and wild range cattle and is especially useful in testing cattle during the hot season in the interior valleys of this

state under conditions that render the subcutaneous method of testing unsatisfactory. It excels the subcutaneous method in economy of time, labor and materials.

From our observations in applying 4926 intradermal tests, including retests, to 4001 head of cattle, 1614 of which reacted, the results being checked by 1000 subcutaneous tests and 341 autopsies we conclude that under average dairy conditions the intradermal equals the subcutaneous method in accuracy, provided a 5 per cent, or stronger, solution of alcoholic precipitated tuberculin is used and the test is performed by an experienced operator. We do not advocate the substitution of the intradermal for the subcutaneous method by a veterinarian until he has become skilled in its use by practice and observation. The practitioner can easily accomplish this in the routine of his work by applying the two tests simultaneously. Such a procedure cannot injure the accepted subcutaneous method in any way, although it may modify the local intradermal swelling to some extent.

Tuberculous cattle usually react thermally, as well as locally to intradermal injections, even when very small doses of tuberculin (1 to 10 miligrams) are used. If temperatures are taken at two-hour intervals from the eighth to the twentieth hours following the intradermal injection it will be found that most of the cattle which react locally will also react thermally.

Since neither the intradermal, the subcutaneous, nor the ophthalmic method will detect every case of tuberculosis when applied independently, the maximum number of reactors can only be detected by applying the combined tests. This may be done by applying the intradermal and subcutaneous tests simultaneously or by administering the intradermal test alone and retesting all of the non-reactors after an interval of at least seven days. The ophthalmic test may also be advantageously combined with either or both of these tests. The ophthalmic test alone is unsuitable for use under the average California dairy conditions, except when only a few animals are to be tested and they can be kept confined under shelter. For official tuberculin testing where a high degree of efficiency is necessary a combination of the three tests would be desirable. The intradermal method is especially adapted to the testing of swine.

# RESULTS OBTAINED WITH TUBERCULIN IN TESTING CATTLE AND HOGS BY THE INTRADERMAL AND OTHER METHODS

BY

CLARENCE M. HARING

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The intradermal or intracutaneous* method of applying the tuberculin test to cattle is now regularly used by several veterinary practitioners in California, and reports from other states and from foreign countries indicate that the method is rapidly gaining favor among veterinarians elsewhere. The test possesses such advantages in economy of time and materials that it has been widely accepted by practitioners as a substitute for the subcutaneous method, without waiting to determine whether it is sufficiently accurate to warrant such an acceptance. The data concerning its accuracy, as compared with that of the usual subcutaneous method, are not sufficient, however, to convince many state officials of the advisability of accepting the intradermal test as a substitute. Another new method of tuberculin testing, called the ophthalmic, conjunctival or eye test, is used in some sections. The ophthalmic method, although not popular in this country, is preferred by some veterinarians. In regard to the acceptance of these methods for the admission of cattle into states requiring a tuberculin test certificate, the following information is of interest. Statements have been received by the writers from the livestock sanitary authorities of thirty-nine states. In Delaware and California the intradermal test is accepted, if performed by an approved veterinarian. The State Veterinarian of Pennsylvania writes that he would not recommend the livestock sanitary board to recognize the method indiscriminately except under certain conditions when the intradermal or ophthalmic tests were made by an unusually well-qualified veterinarian and a certificate for physical examination accompanied a report of the test. The State Veterinarian of Missouri writes: "We are using the intradermal test exclusively in our state

* The terms intradermal and intracutaneous are synonyms. Custom renders the word intradermal preferable, when mentioned in connection with the testing of cattle.

work, but for interstate shipments we are using the thermal method, for the reason that the intradermal leaves no record. Therefore, until such time as an agreement can be made between the different states and there is a better system for the control of the veterinarians, it will be necessary for us to require the thermal test and a record of the same filed in this office immediately after the inspection is made. We have the greatest confidence in the intradermal test and would not hesitate to accept shipments where it has been applied, except for the fact that only a very small per cent of the veterinarians doing interstate work are familiar with the intradermal test. Therefore, I see no possibility of our accepting the intradermal test in the near future.'' Most of the state authorities agree that they cannot as yet officially accept either the intradermal or ophthalmic method. The concensus of opinion seems to be that these tests are fairly satisfactory when administered by careful and experienced operators, but that it is unsafe to accept such tests from veterinarians indiscriminately, until these methods have come into more general use and have been accepted by the United States Bureau of Animal Industry.

## LOCAL TUBERCULIN REACTIONS AND THEIR USE FOR DIAGNOSIS IN HUMAN AND VETERINARY PRACTICE

In human practice* the intradermal method is used to some extent, but many physicians consider this method too delicate for routine diagnosis in man. Their objection is that the test is so searching in its scrutiny that it causes reactions in latent cases which would probably never develop active tuberculosis.

In veterinary practice, however, this ''searching scrutiny'' is usually desired and from data already available there is reason to believe that this test *when combined with observations concerning the*

* The tissues of tuberculous persons and animals are sensitive to tuberculin. This sensitiveness is most marked in the tissues that are actually invaded by the germs, but it also exists to some extent in the other tissues of the body which contain blood vessels. The living tissues of individuals who have not been infected with tuberculosis show no sensitiveness to tuberculin.

Attention was first called to the possibilities of the intradermal injection of tuberculin as a means of diagnosis by Mendel, who suggested that the procedure followed in the intradermal method of injecting for anesthesia would be a delicate and satisfactory means of diagnosis. The suggestion was soon put into practice by Mantoux and others. According to Hamman and Wolman,[12] the intradermal method when applied to man has no equal as a means of estimating the degree of tuberculin hyper-sensitiveness. They conclude from a study of the records of a large number of tests made by the various methods of tuberculin testing that the intradermal and subcutaneous local tests are the most delicate tests for man. They reveal practically the full percentage of tuberculosis infected individuals. In the order of their sensitiveness the tests

*thermal reaction furnishes a more accurate means of diagnosis than the usual subcutaneous method of testing cattle*, in which no attention is paid to the local reaction and no attempt is made to select and prepare the field of injection and to inject in such a way that if the local reaction occurs it will be easily detected. Many veterinarians in making the subcutaneous test shave the neck at the point where the subcutaneous injection is to be made, in order to more easily observe the local reaction which frequently occurs. Corbett and Griffiths[6] state that the local reactions resulting from subcutaneous injections in the neck were usually very slight and of no special value. However, we have found that in interpreting doubtful thermal reactions it is of assistance to examine the site of injection for local swellings. One of us (Bell) has found it of value, in testing by the subcutaneous method, to inject the tuberculin through the skin of the hindquarter over the semimembranosis muscle. He finds that the local reactions to the subcutaneous injections are more clearly defined than in the loose tissues of the neck. The intradermal method excels the subcutaneous in the size and definiteness of its local reactions.

## TECHNIC OF THE INTRADERMAL METHOD

The manner in which the intradermal differs from the usual subcutaneous test is that the tuberculin is injected in $\frac{1}{20}$ to $\frac{1}{4}$ cc. amounts into the deeper layers of the skin, or into the subdermal tissue immediately adjacent, instead of injecting a large quantity (1 to 4 cc.) deeply under the skin. The most suitable place to make this injection is in one of the folds of the skin on the under side of the base of the tail. We have used the skin of the neck in some of our tests, but find the subcaudal fold more convenient. The skin

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for tuberculosis in man arrange themselves according to Hamman and Wolman[11] as follows:

**Intracutaneous test (Intradermal)**
**Subcutaneous-local test (Strichreaction)**
**Cutaneous test (von Pirquet)**
**Subcutaneous test (Koch)**
**Percutaneous test (Moro inunction)**
**Conjunctival test (Calmette ophthalmic).**

As a means of diagnosis of tuberculosis in man, the first two tests are said by these writers to be undesirable for the very reason that they detect even the latent cases of infection. They state that in adult life and even in late childhood the subcutaneous local reaction is of absolutely no diagnostic value, since only an occasional individual will escape its searching scrutiny. What little diagnostic value it has is restricted to the first two years of life and even at that age it has no marked value above the cutaneous test for the reason that these tests have shown the astonishing extent to which man is tuberculosis infected and at what an early age the infection occurs.

here is free from hair and is soft and pliable. A hypodermic syringe with a short needle point should be used. Such a syringe should have a 25 or 26 gage needle with a point $\frac{3}{16}$ to $\frac{1}{4}$ of an inch in length, similar to those used by dentists for injecting local anaesthetics (see plate 1, figures 1 and 2).

The subcaudal fold is grasped between the thumb and the first two fingers of the left hand and the needle inserted horizontally into the thickness of the skin grasped between the thumb and finger (see plate 2, figure 1). The $\frac{1}{10}$ or $\frac{1}{5}$ cc. dose, if properly placed, can be felt in the layers of the skin as it is expelled from the syringe, where it remains as a small lump in the skin after the needle has been removed. In our first tests we made the mistake of trying to inject as near the surface of the skin as possible. It is difficult to inject into the layers of the epidermis and an injection into this part of the skin is of little diagnostic value. In case the needle is of the proper length, namely, one-quarter of an inch, there is little danger of going completely through the skin. When the proper point in the subcaudal fold is selected, it makes little difference whether the point of the needle is in the derma or in the subdermal connective tissue. With the proper syringe an expert operator can inject in the dark as accurately as in a good light. We have found that characteristic reactions occur with the injections from a long needle, placed completely through and beneath the skin layers of the subcaudal fold. It is well to inject at a point on the fold about two and one-half or three inches down the tail from the anus, since elsewhere reactions are not so easily perceived and at this point the bone and solid tissue of the tail form a background which renders the local reactions more prominent than those of the skin of the neck.

After successfully using the intradermal method on fifteen hundred head of cattle, Longley[23] has expressed the opinion that it is impossible to inject into the skin proper, but that the dose goes into the subdermal connective tissue. From experiments which we have made on the hides of recently killed cattle, we think he must have meant the epidermis. When a one-quarter inch needle is inserted slightly horizontally into the subcaudal fold it rarely penetrates deeper than the lower layers of the derma or true skin.

In injecting cattle that are secured in stanchions, a convenient way is to stand by the side of the cow, as shown in plate 2, figure 1, pressing the knee into the animal's flank and grasping the loose folds of skin from under the tail without raising the tail. Some operators, when injecting, prefer to stand directly behind the cow, as shown in plate 2, figure 2, but this method is impracticable except with very

docile cattle or when an assistant is available to steady the animal and keep her from moving from side to side.

We deem it impracticable to disinfect or otherwise prepare the subcaudal fold for the intradermal injection, except when it is soiled. In such cases, wipe the fold clean with a rag, apply 50 per cent alcohol with absorbent cotton and wipe with dry cotton. Before injecting each animal, the syringe needle should be dipped in strong disinfectant, and wiped dry with sterile absorbent cotton. After dipping the needle in an irritating disinfectant, take pains to wipe it off before inserting it, for the disinfectant may cause irritation and produce a swelling which might be mistaken for a reaction. The application of strong disinfectants at the point of intradermal injection should be avoided. In several instances we have observed swellings, varying in size from a hazelnut to a hen's egg, on the subcaudal fold as a result of the application of strong lysol solution. These might have been mistaken for reactions, but for the fact that the cattle were not injected with tuberculin (see plate 6, figure 1).

## KIND AND STRENGTH OF TUBERCULIN FOR INTRADERMAL USE

From experiments which we have conducted during the past year, we believe that a strong solution of *alcoholic precipitated tuberculin** is most suitable for use with the intradermal test in cattle. In order

* Laboratories vary considerably in their methods of preparing precipitated tuberculin. Most of the tuberculin which we have used has been prepared as follows: To twenty volumes of absolute alcohol add very slowly one volume of Koch's Old Tuberculin concentrated. Stir thoroughly and set aside for twenty-four hours. At the end of this time a floculent deposit will be seen in the bottom of the vessel. The supernatant fluid is decanted and the partially dried precipitate redissolved in one volume of 1 per cent sodium chloride solution and the tuberculin reprecipitated by adding this solution to twenty volumes of absolute alcohol. The supernatant fluid is decanted and the precipitate washed by adding it to nine volumes of absolute alcohol. The precipitate is then placed on clay plates, put in a dessicator and, under vacuum, dried over sulphuric acid. A brownish powder can be scraped from the plate. This is the *precipitated tuberculin;* also known as dry tuberculin or tuberculin siccum. This tuberculin is said to be soluble in the proportion of one part by weight to ten of water, but higher concentrations can sometimes be obtained. We have been able to make 50 per cent solutions. According to Brieger and Proskauer,[5] one-tenth of a gram of this precipitated tuberculin produces the same effect as five-tenths of a gram of crude tuberculin (Koch's Old). According to Hamman and Wolman this kind of tuberculin seems to be more toxic to animals than Koch's Old Tuberculin.

This may be dispensed in powder form to be made into a solution when needed. Most laboratories, however, prepare the solution before shipment, a diluent of ½ per cent of trikresol being added and the solution sterilized by steaming at 60° C. for thirty minutes.

The concentrated tuberculin used in preparing the precipitated should be made from selected cultures. The culture media used should be prepared according to standard methods, using veal broth and not that prepared from commercial extract of beef. We have found some of the precipitated tuberculin on the market to be of low potency.

to obtain a distinct and well-marked subcaudal reaction this purified tuberculin should be used in at least a 5 per cent solution (50 milligrams per cc. of physiological salt solution) administering doses of between $\frac{1}{10}$ and $\frac{1}{5}$ cc. The injection of ten times this dose ($\frac{1}{2}$ cc. of 25 per cent solution) subcaudally leaves no perceptible swelling in non-tuberculous animals after the forty-eighth hour while in tuberculous cattle a swelling the size of an egg usually results. Vallee[48] and his co-workers endeavored to obtain the subcaudal reaction with the minimum dose, but in order to obtain the maximum number of reactions in tuberculous cattle, we believe it is desirable to use a stronger solution than they suggest. This point is discussed later in connection with tuberculin manufactured by various firms. Ten per cent solutions of potent precipitated tuberculin (100 milligrams per cc. of physiological salt solution) will usually produce pronounced local and thermal reactions in tuberculous cattle, when administered intradermally.

Koch's Old Tuberculin in 10 per cent solution has also given good results as can be seen by an inspection of Tables 1 and 2. The tuberculin distributed by the Bureau of Animal Industry for official use is equivalent to 10 per cent Koch's Old Tuberculin and for the practictioner who can obtain it this tuberculin will doubtless prove more satisfactory than the solutions of tuberculin sold for intradermal use by biological houses.

We have also obtained excellent results in both the intradermal and ophthalmic work with *phymatin,* a tuberculin of unknown content manufactured in Germany.

Hutyra and Marek[15] have suggested that the tuberculins which contain ground or pulverized tubercle bacteria will probably be found to be most potent in producing local reactions. In view of this we tried two such preparations which, by courtesy of the Cutter Laboratory, were manufactured especially for these experiments. One of these consisted of a glycerin free suspension of finely ground tubercle bacilli. The other consisted of a similar suspension of whole tubercle bacilli killed by steaming for two hours at 60° C. The emulsions contained a solid content of from 10 to 20 milligrams tubercle bacilli per cc. In tuberculous animals no local or thermal reactions resulted from the intradermal injection of $\frac{1}{10}$ cc. doses of these suspensions.

*Precautions Against the Deterioration of Precipitated Tuberculin.* —Meyer[33] has called attention to the fact that aqueous solutions of alcoholic precipitated mallein disintegrate rapidly, due in part to the absence of preservative and in part to changes in toxin molecules. Therefore, the powder form alone can be kept in stock and the test

solution should always be made shortly before use. It is probable that this holds true for solutions of precipitated tuberculin as well. As a diluent for the dry tuberculin we have used ¼ per cent solutions of trikresol in physiological salt solution and, if the dilution is prepared aseptically, we have found that the tuberculin dilution will remain sterile and potent for months. The use of trikresol or phenol in ¼ to ½ per cent solutions for the intradermal test does not appear to produce a perceptible local irritation or be objectionable in any way. On account of the possibility of molecular disintegration, however, we advise that the test solution be prepared shortly before use. It is convenient to keep on hand a stock of sterile 2 cc. amber glass bottles, each bottle containing one-tenth of a gram of dry alcoholic precipitated tuberculin. By adding to one of these 2 cc. of sterile physiological salt solution, ten doses of 5 per cent tuberculin solution can be prepared. As the tuberculin powder goes into solution very slowly, the diluent should be added at least two hours before the injection is to be made. On account of the detrimental effect of light on such solutions they should be kept in amber bottles and protected from direct sunlight as much as possible.

*Lack of Uniformity in Tuberculin.*—In the United States there is a great lack of uniformity regarding the tuberculin used. We have purchased "intradermal" tuberculin from six different firms, and in only two instances has the product been the same, as is shown by the following:

*Firm A* recommends for the intradermal test in cattle a tuberculin bearing the label "Tuberculin O. T. (Original) Serial Dilution No. 5, 1 cc. contains 100 mg." This they state is prepared by diluting one part of Koch's Old Tuberculin with nine parts of physiological salt solution containing ¼ per cent trikresol.

Recently this firm has placed on the market "Intradermal Tuberculin, Veterinary," which is essentially the same as the above in strength, although in its preparation it is not deemed necessary to concentrate the original culture down to the full equivalent of Koch's old tuberculin before diluting it back to the strength of dilution No. 5.

On request they will also furnish for the intradermal test dilutions of alcoholic precipitated tuberculin, glycerin free, in any dilution desired up to 10 per cent solution.

*Firm B* recommends for the intradermal test of cattle a tuberculin bearing the label "Solution Purified Tuberculin for Intradermal Test. Each cc. contains 50 milligrams purified and precipitated Tuberculin in sterilized normal salt solution. Dose—1 to 5 minims." On request, this firm will also furnish for the intradermal test stronger solutions of alcoholic precipitated tuberculin.

*Firm C* recommends for the intradermal test in cattle "Ordinary Veterinary Tuberculin." This is presumably similar to that distributed by the Bureau of Animal Industry for the use of state and municipal officials.

*Firm D* states that they do not dispense any especially prepared tuberculin for the intradermal test, but recommends their "concentrated tuberculin." The label on this tuberculin reads as follows: "Tuberculin, Veterinary, ready for use." This firm advises us by letter that this concentrated tuberculin is seven times the strength of the ordinary culture and contains 35 per cent glycerin.

*Firm E* recommends a 50 per cent solution of Koch's old tuberculin. This corresponds with the recommendations of Hutyra and Marek, Joseph and others. This firm writes that they also dispense a purified tuberculin of strength equivalent to the above for intradermal use. They are not able to state the method of the preparation of this tuberculin, as it is manufactured in a foreign laboratory.

*Firm F* recommends tuberculin especially prepared for the intradermal testing of cattle. This firm could not give any particulars regarding the contents of the tuberculin or its method of preparation, as it was manufactured in a foreign laboratory.

In view of the diversity of tuberculins recommended for the intradermal test, the following information concerning the relative merits of alcoholic precipitated tuberculin versus Koch's old tuberculin is of interest:

*Alcoholic Precipitated Tuberculin.*—Using alcoholic precipitated tuberculin in solutions varying from ½ to 50 per cent, we have tested by the intradermal method 2312 cattle, 1190 of which reacted with clear and positive results. In one instance where dry alcoholic precipitated tuberculin was purchased from a certain laboratory and used intradermally on tuberculous cattle in 10 per cent solutions it gave very weak or negative results. Tests made with "purified tuberculin" of foreign manufacture and unknown strength have also given unsatisfactory results. We are now making tests on guinea-pigs to show the comparative toxicity of tuberculins from various manufacturers, the preliminary results of which indicate that tuberculins sold in this country vary considerably in strength. Government supervision and standardization of biological products, especially tuberculin, is greatly needed. When a potent precipitated tuberculin is not available it is preferable to Koch's Old Tuberculin for intradermal use. Our reasons for prefering the precipitated tuberculin to dilutions of Koch's Old Tuberculin are as follows:

In thirty-two of our intradermal tests with Koch's Old Tuberculin, the results were checked by injecting the opposite subcaudal fold with ⅕ cc. of physiological salt solution, containing 5 per cent glycerin and ½ per cent phenol, a new clean syringe being used. The swellings produced by the glycerin in two cases were persistent enough to be confusing. We then undertook extensive trials concerning the effect of solutions of glycerin, phenol and trikresol when injected intradermally and found that the glycerin in solutions of 5 per cent or stronger would frequently produce swellings large enough to be confusing when injected in ⅕ cc. doses. The trikresol and phenol in ½ per cent solutions on intradermal injection did not produce swellings.

We also tried the effect of injecting 10 per cent solutions of the precipitates derived by treating concentrated glycerin bouillon with alcohol in a manner similar to that used in producing precipitated tuberculin. These did not produce swellings large enough to be confused with an intradermal reaction.

Our observations in this respect corroborate the observations of Vallee, Declaire and Herbert.[48] They state that many healthy cattle, subjected to the intradermal test according to the method of Moussu and Mantoux,[35-37] show in about 6 per cent of the cases an immediate local swelling, at periods of time varying from five to sixty minutes after injection. This swelling at the site of the injection is edematous in character and varies in size from the dimensions of a hazelnut to those of a plum. The swelling disappears quickly, rarely persisting more than twenty-four hours, differing in this respect from the specific reaction in tuberculous animals, which is usually more persistent. Some cases, however, in healthy cattle persist more than forty-eight hours. The above authorities assume that the swelling is brought about in part by the glycerin or by certain salts in the bouillon and that it may be in part a reaction to a traumatism. According to Mulford's Veterinary Bulletin, they recommend the use of ½ per cent precipitated tuberculin solution with ⅕ cc. doses.

Under certain conditions, when the intradermal is to be followed by a subcutaneous test, it might be desirable to use this weak solution of tuberculin, as there would be less likelihood of its having an inhibitory effect on the subsequent test. In fact, Hamman and Wolman claim there is reason to believe that the injection of $\frac{1}{10}$ cc. doses of ½ per cent tuberculin in a human being may have a sensitizing effect which will render a subsequent test more effective. We have no evidence to show that this holds true for cattle.

Foth[11] states that the dose used by the French authors was too small to get the maximum number of local reactions. This is probably true, but from our experiments we believe that the quantity of liquid injected should not exceed ⅕ cc. and that it is better to increase the concentration of the tuberculin instead of increasing the quantity of the dose. Most authorities prefer to use Koch's old tuberculin for the intradermal test and we would be inclined to agree in this if it were not for its glycerin content.

*Koch's Old Tuberculin (Tuberculin O. T. Original).*—Hutyra and Marek[14] state that a 50 per cent solution of Koch's old tuberculin, when injected intradermally, produces good clear results in both positive and negative cases. Several veterinarians who have had extensive experience in the use of tuberculin inform me that the ordinary B. A. I. tuberculin, undiluted, in doses of three to five drops, has given excellent results and that from a long series of tests in actual practice they do not believe it necessary to use purified tuberculin.

Joseph[16] has stated that not over ⅕ cc. should be injected, and we believe from our work that his suggestions should be followed, provided a strong solution of tuberculin is used. Joseph used 1/20 cc. of Koch's old tuberculin diluted with an equal amount of physiological salt solution, which would make a solution containing 25 per cent glycerin.

Using Koch's old tuberculin according to the method of Moussu and Mantoux,[37] we have tested by the intradermal method 1942 cattle, 477 of which reacted with clear and positive results. We have concluded, however, after due experimentation and consideration of the recommendations of the investigators and firms above mentioned, that a strong solution of alcoholic precipitated tuberculin is preferable to Koch's old tuberculin for the intradermal test in cattle.

The summary given in Table 1 is of interest in considering the relative merits of the various kinds and strengths of tuberculin recommended for the intradermal method.

In addition to the tests mentioned in Table 1, we have experimented with aqueous glycerin free suspensions of finely ground tubercle bacilli, also with suspension of whole tubercle bacilli which had been killed by heat, and with *phymatin,* a German preparation of unknown composition highly recommended for the ophthalmic and intradermal tests.

A summary of the autopsies on tested cattle is given in Table 2.

TABLE 1

RESULTS FROM THE INTRADERMAL USE OF VARIOUS SOLUTIONS OF TUBERCULIN

| Kind of tuberculin | Dose | Total number of cows tested | Total number of reactions | Conclusions regarding the tuberculin |
|---|---|---|---|---|
| Koch's old tuberculin dilution 1 to 10 of physiological salt solution. | 1/10 to 1/5 cc. | 1942 | 477 | Fairly satisfactory. Produces distinct local reaction swellings, but the glycerin which it contains causes a swelling immediately after injection which occasionally persists long enough in healthy cattle to be confusing. Thermal reactions also occur with this dosage. |
| Concentrated tuberculin equal in strength to a 70 per cent solution of Koch's old tuberculin. | 1/10 to 1/5 cc. | 15 | 11 | The tuberculin contains 35 per cent glycerin. The glycerin content is objectionable. |
| Koch's old tuberculin undiluted. | 1/10 cc. | 24 | 0 | Used on 24 head of non-reacting cattle. The swellings due to the glycerin in some cases were four inches in diameter and persisted over 48 hours. |
| Alcoholic precipitated tuberculin 10 per cent solution (100 milligrams per cc. of physiological salt solution). | 1/20 to 1/5 cc. | 201 | 48 | This kind of tuberculin in strengths of 5 to 50 per cent is very satisfactory. It produces pronounced local and thermal reactions when injected intradermally in 1/10 cc. doses. No local swellings occur in non-tuberculous cattle. |
| Alcoholic precipitated tuberculin 5 per cent solution (50 milligrams per cc.). | 1/10 to 1/5 cc. | 937 | 630 | |
| Alcoholic precipitated tuberculin 2 per cent solution (20 milligrams per cc.). | 1/5 cc. | 1055 | 479 | Fairly satisfactory. Produces thermal as well as local reactions when injected intradermally. A stronger solution is better. |
| Alcoholic precipitated tuberculin ½ per cent solution (5 milligrams per cc.). | 1/5 cc. | 119 | 33 | Too weak except when the cattle are to be retested with stronger tuberculin. This strength of tuberculin produces moderate local and thermal reactions when injected intradermally. |
| A tuberculin of foreign manufacture recommended for intradermal use. Strength unknown. | 1/5 cc. | 17 | 4 | The firm selling this tuberculin was unable to state its strength, saying it was manufactured in a foreign country. The autopsies proved this tuberculin unsatisfactory. |
| Total tests. | | 4310 | 1682 | Autopsies were made in 341 cases. See notes following. |
| Subtracting for re-tests. | | 521 | 136 | |
| Number of cattle tested. | | 3789 | 1546 | |

### AUTOPSY NOTES

Herd No. 1.—Fifteen cattle, which showed physical signs of tuberculosis, were injected with ⅕ cc. of a 10 per cent dilution of Koch's old tuberculin, and fourteen reacted. One week later they were tested by the subcutaneous method and all reacted. On autopsy they were found to be tuberculous. (See Table 6.)

Herd No. 3.—In testing a herd of 209 cattle, using the intradermal and subcutaneous methods simultaneously, one cow reacted to the subcutaneous test and another to the intradermal test. On autopsy these two were found tuberculous. (See cases 9 and 11, p. 132; also Table 6.)

Herd No. 6.—Two cattle that reacted locally to an intradermal injection of ⅕ cc. of a 10 per cent dilution of Koch's old tuberculin failed to react to subcutaneous tests applied three to thirty days later. They were found tuberculous on autopsy. (See cases 3 and 4, p. 130.)

Herd No. 8.—One hundred and seventy-two cattle, when tested after the method of Moussu, gave 124 reactions. Only two of these were autopsied, and both were found tuberculous. In addition, we observed thirty cows in this herd that evidenced physical signs of tuberculosis, several having symptoms of udder lesions. All of the physical cases reacted. (See Table 6, herd 8.)

Herd No. 9.—A certified herd of twenty-five cattle which had been tested semi-annually by the subcutaneous method and found free from reactions for five years was tested by the method of Moussu and one cow reacted. On autopsy she was found tuberculous. (For detailed description of this, see cow 1, p. 129.)

Herd No. 10.—Four out of eleven local reactors to concentrated tuberculin, containing 35 per cent glycerin, injected intradermally, failed later to react subcutaneously. Three of these were autopsied and tuberculous lesions found in two. It is not known whether the failure to find lesions in the third was due to the fact that only a hasty autopsy was made, or to the fact that the local swelling on this cow was due to the glycerin and not to a reaction. (See cases 2, 5, and 6, p. 130.)

Herd No. 13.—Thirty-five cattle tested intradermally with 2 per cent precipitated tuberculin gave fourteen reactions. Four of these were autopsied and all four contained tuberculous lesions.

Herd No. 24.—Thirty-six cattle were tested after the method of Moussu. One reacted. The entire thirty-six were autopsied and no tuberculous lesions were found. It is not known whether the failure to find lesions in the one showing the local swelling was due to the fact that only a hasty autopsy could be made or to the fact that the local swelling was caused by the glycerin and was not a reaction.

Herd No. 25.—Seventeen cattle were tested intradermally with a tuberculin of foreign manufacture. Four of them reacted. The entire seventeen were autopsied. Lesions could be found in only three of these. Two cattle which failed to react were found to have lesions. Obviously the tuberculin was defective.

Herd No. 29.—Eight hundred and eighteen cattle belonging to Dairy Company A were tested intradermally, using 5 per cent precipitated tuberculin, and 585 cattle reacted. There has been opportunity to autopsy only seven of these reactors. All but one of them showed tuberculous lesions. In addition, eight animals presumably physical cases of tuberculosis were found in the dairy, all of which reacted to the intradermal test.

Herd No. 30 35.—Two thousand one hundred and eighty-four cattle, belonging to Company B, were tested by the intradermal method, using various strengths of tuberculin, and 775 reacted. There has been an opportunity to autopsy thirty-two of the reactors, tuberculous lesions being found in all but one of these. Seven of the non-reactors were autopsied and all but one were found free from tuberculous lesions. The lesions in the tuberculous non-reacting animal were very extensive and the failure of the animal to react can be explained by the well-known fact that cattle having advanced tuberculosis frequently are not sensitive to tuberculin.

*Miscellaneous Autopsies.*—At various abattoirs in the San Francisco Bay region we have applied the intradermal test to 212 cattle and two or three days later have examined them on the killing floor. Various kinds of tuberculin were used. The results of these tests, together with the autopsies of cattle from the above mentioned herds are summarized in the following table:

TABLE 2

RESULTS OF INTRADERMAL TESTS AND AUTOPSIES

| Kind of Tuberculin | Cattle in which tuberculous lesions were found | | | Cattle in which no tuberculous lesions were found | | |
|---|---|---|---|---|---|---|
| | Number tested | Number reacted | Per cent reacted | Number tested | Number reacted | Per cent reacted |
| 10 per cent Koch's Old | 27 | 25 | 92.6 | 36* | 1 | 2.8 |
| 25 to 100 per cent Koch's Old | 2 | 2 | 100.0 | 9 | 2 | 22.2 |
| ½ to 2 per cent precipitated | 36 | 34 | 94.4 | 10 | 1 | 10.0 |
| 5 to 10 per cent precipitated | 46 | 44 | 95.6 | 93 | 5 | 5.3 |
| 50 per cent precipitated | 5 | 5 | 100.0 | 24 | 2 | 8.3 |
| Phymatin | 13 | 13 | 100.0 | 23 | 1 | 4.3 |
| Foreign purified tuberculin | 5 | 3 | 60.0 | 12 | 1 | 8.3 |

* These thirty-six cattle were from ranges in Nevada where tuberculosis is rare, but there is reason to believe that the swelling was not a reaction but due to the glycerin in the tuberculin.

† Possibly not reactions. The swellings may have been due to glycerin in the tuberculin.

## TABLE 3

INTRADERMAL TESTS WITH KOCH'S OLD TUBERCULIN IN 10 PER CENT SOLUTIONS AND PRECIPITATED TUBERCULIN IN 5 TO 10 PER CENT SOLUTIONS. RESULTS AND AUTOPSIES

| Herd No. | Cow No. | Kind of tuberculin | Test result | Autopsy result | Physical condition and symptoms | Tuberculosis Lesions | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Cervical glands | Thoracic glands | Lungs | Pleura | Liver | Uterus or Ovaries | Other abdominal lesions | Udder | Other lesions |
| 1 | 1 | 10% O. T. | + | + | Bad, Lung symptoms | ..... | XXX | XXX | X | ..... | ..... | X | ..... | ..... |
| | 2 | 10% O. T. | + | + | Poor, Jaw abscess | XXX | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | 3 | 10% O. T. | + | + | Emaciated, Dyspnea | X | XX | XXX | ..... | ..... | ..... | X | ..... | ..... |
| | 4 | 10% O. T. | + | + | Fair, Lung symptoms | ..... | X | XX | X | ..... | ..... | ..... | ..... | X |
| | 5 | 10% O. T. | + | + | Poor, Cough | ..... | X | XX | ..... | X | ..... | X | ..... | X |
| | 6 | 10% O. T. | — | + | Emaciated, Cough | X | XX | XXX | XX | ..... | ..... | ..... | ..... | X |
| | 7 | 10% O. T. | + | + | Poor, Lung symptoms | X | XX | XX | X | X | ..... | X | ..... | XX |
| | 8 | 10% O. T. | + | + | Fair, Lung symptoms | ..... | X | X | X | ..... | ..... | X | ..... | ..... |
| | 9 | 10% O. T. | + | + | Poor, Lung symptoms | ..... | X | XX | ..... | XX | ..... | X | ..... | ..... |
| | 10 | 10% O. T. | + | + | Fair, No symptoms | ..... | X | XX | ..... | ..... | ..... | ..... | ..... | ..... |
| | 11 | 10% O. T. | + | + | Good, No symptoms | X | ..... | XX | ..... | ..... | ..... | ..... | ..... | ..... |
| | 12 | 10% O. T. | + | + | Good, No symptoms | ..... | X | X | ..... | ..... | ..... | ..... | ..... | ..... |
| | 13 | 10% O. T. | + | + | Fair, No symptoms | ..... | X | X | ..... | ..... | ..... | ..... | ..... | ..... |
| | 14 | 10% O. T. | + | + | Fair, No symptoms | ..... | ..... | ..... | ..... | ..... | ..... | X | ..... | ..... |
| | 15 | 10% O. T. | + | + | Fair, No symptoms | X | X | XX | ..... | ..... | ..... | ..... | ..... | ..... |
| 3 | 1 | 10% O. T. | + | + | Good, No symptoms | ..... | X | ..... | ..... | ..... | ..... | X | ..... | ..... |
| | 2 | 10% O. T. | — | + | Good, No symptoms | X | X | ..... | ..... | X | ..... | ..... | ..... | ..... |

TABLE 3—*Continued*

| Herd No. | Cow No. | Kind of tuberculin | Test result | Autopsy result | Physical condition and symptoms | Tuberculosis Lesions: Cervical glands | Thoracic glands | Lungs | Pleura | Liver | Uterus or Ovaries | Other abdominal lesions | Udder | Other lesions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 1 | 10% O. T. | + | + | Fair, No symptoms | ..... | × | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | 2 | 10% O. T. | + | + | Fair, No symptoms | ..... | × | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | 3 | 10% O. T. | + | + | Fair, No symptoms | ..... | × | × | ..... | ..... | ..... | ..... | ..... | ..... |
| 8 | 1 | 10% O. T. | + | + | Fair, No symptoms | ..... | × | ×× | ..... | ..... | ..... | ..... | ..... | ..... |
| | 2 | 10% O. T. | + | + | Poor, Lung symptoms | ..... | × | ×× | ..... | ..... | ..... | × | ..... | ..... |
| 9 | 1 | 10% O. T. | + | + | Good, No symptoms | × | ..... | ..... | ..... | ..... | ..... | × | ..... | ..... |
| 24 | 1 | 10% O. T. | + | — | Excellent, No symptoms | No lesions found. | | | | | | | | |
| Miscellaneous | 1 | 10% O. T. | + | + | Thin, Lung symptoms | ..... | × | ×× | × | × | ..... | × | ..... | ..... |
| | 2 | 10% O. T. | + | + | Emaciated, Lung symptoms | ..... | ××× | ××× | × | ..... | ..... | ..... | ..... | × |
| | 3 | 10% O. T. | + | + | Emaciated, Lung symptoms | ..... | ×× | ×× | ..... | ..... | ..... | ..... | ..... | ..... |
| | 4 | 10% O. T. | + | + | Emaciated, Lung symptoms | ..... | × | ×× | × | × | ..... | × | ..... | × |
| 29 | 1 | 5% precipitated | + | + | | * | | | | | | | | |
| | 2 | 5% precipitated | + | + | | * | | | | | | | | |
| | 3 | 5% precipitated | + | + | | * | | | | | | | | |
| | 4 | 5% precipitated | + | + | | * | | | | | | | | |
| | 5 | 5% precipitated | + | + | | * | | | | | | | | |
| | 6 | 5% precipitated | + | + | | * | | | | | | | | |
| | 7 | 5% precipitated | + | — | | No lesions found. | | | | | | | | |

* Autopsy notes lost.

TABLE 3—*Continued*

| Herd No. | Cow No. | Kind of tuberculin | Test result | Autopsy result | Physical condition and symptoms | Tuberculosis Lesions | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Cervical glands | Thoracic glands | Lungs | Pleura | Liver | Uterus or Ovaries | Other abdominal lesions | Udder | Other lesions |
| 30–35 | 1 | 5% precipitated | + | + | Udder tuberculosis | ×× | × | × | ..... | ..... | ..... | ..... | ××× | ..... |
| | 2 | 5% precipitated | + | + | Thin, Lung symptoms | × | ×× | ×× | × | ..... | ..... | ×× | ..... | ..... |
| | 3 | 5% precipitated | + | + | Emaciated, Dyspnea | ×× | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | 4 | 5% precipitated | + | + | Thin, Lung symptoms | ×× | ×× | ×× | × | ..... | ..... | × | ..... | ..... |
| | 5 | 5% precipitated | + | + | Emaciated, Lung symptoms | ××× | ××× | ××× | ××× | ××× | ××× | ××× | ××× | ..... |
| | 6 | 5% precipitated | + | + | Emaciated, Lung symptoms | ..... | ×× | ××× | ×× | ..... | ..... | × | ..... | ..... |
| | 7 | 5% precipitated | + | + | Thin, Lung symptoms | ..... | ××× | ..... | ..... | ..... | ..... | × | ..... | ..... |
| | 8 | 5% precipitated | — | + | Emaciated | ..... | ××× | ××× | ××× | ××× | ..... | ××× | ..... | ..... |
| | 9 | 5% precipitated | + | + | Fair, No symptoms | ..... | × | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | 10 | 5% precipitated | + | + | Fair, No symptoms | ..... | × | ..... | ..... | ..... | ..... | × | ..... | ..... |
| | 11 | 5% precipitated | + | + | Fair, No symptoms | ..... | × | × | ..... | ..... | ..... | × | ..... | ..... |
| | 12 | 5% precipitated | + | + | Fair, No symptoms | ..... | ×× | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | 13 | 5% precipitated | + | + | Fair, No symptoms | ..... | × | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | 14 | 5% precipitated | + | + | Fair, No symptoms | ..... | × | ..... | ..... | ..... | ..... | × | ..... | ..... |
| | 15 | 5% precipitated | + | + | Fair, No symptoms | × | × | × | ..... | ..... | ..... | ..... | ..... | ..... |
| | 16 | 5% precipitated | + | + | Fair, No symptoms | ..... | × | × | ..... | ..... | × | × | ..... | ..... |
| | 17 | 5% precipitated | + | + | Fair, No symptoms | ..... | × | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | 18 | 5% precipitated | + | + | Fair, No symptoms | ..... | × | × | ..... | × | ..... | × | ..... | ..... |
| | 19 | 5% precipitated | + | + | Fair, No symptoms | ..... | × | × | ..... | ..... | ..... | × | ..... | ..... |
| | 20 | 5% precipitated | + | + | Fair, No symptoms | ..... | × | ×× | ..... | ..... | ..... | × | ..... | ..... |
| | 21 | 5% precipitated | + | + | Fair, No symptoms | ..... | ..... | ..... | ..... | ..... | ..... | × | ..... | × |
| | 22 | 5% precipitated | + | + | Fair, No symptoms | ..... | × | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | 23 | 5% precipitated | + | — | Fair, No symptoms | No lesions found. | | | | | | | | |
| | 24 | 5% precipitated | + | + | Fair, No symptoms | ..... | × | ..... | ..... | ..... | ..... | × | ..... | ..... |

TABLE 3—*Concluded*

| Herd No. | Cow No. | Kind of tuberculin | Test result | Autopsy result | Physical condition and symptoms | Tuberculosis Lesions: Cervical glands | Thoracic glands | Lungs | Pleura | Liver | Uterus or Ovaries | Other abdominal lesions | Udder | Other lesions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30–35 | 25 | 5% precipitated | + | + | Fair, No symptoms | ..... | ×× | ×× | ..... | ×× | ..... | × | ..... | ..... |
| | 26 | 5% precipitated | + | + | Fair, No symptoms | ..... | ×× | ×× | ..... | ..... | ..... | ..... | ..... | ..... |
| | 27 | 5% precipitated | + | + | Fair, No symptoms | ..... | ..... | ..... | ..... | ..... | ..... | × | ..... | ..... |
| | 28 | 5% precipitated | + | + | Fair, No symptoms | ..... | ..... | ..... | ..... | ..... | ..... | × | ..... | ..... |
| | 29 | 5% precipitated | + | + | Fair, No symptoms | ..... | ..... | ×× | ..... | ..... | ..... | ..... | ..... | ..... |
| | 30 | 5% precipitated | + | + | Fair, No symptoms | ..... | × | ×× | ..... | ..... | ..... | × | ..... | ..... |
| | 31 | 5% precipitated | + | + | Fair, No symptoms | ..... | × | ..... | ..... | ..... | ..... | × | ..... | ..... |
| | 32 | 5% precipitated | + | + | Fair, No symptoms | ..... | ..... | × | ..... | ..... | ..... | ..... | ..... | ..... |
| | 33 | 5% precipitated | + | + | Fair, No symptoms | ..... | ..... | ..... | ..... | ..... | ..... | × | ..... | ..... |
| Miscellaneous | 1 | 10% precipitated | + | + | Poor, Lung symptoms | ..... | ×× | ××× | ×× | ..... | ×× | ×× | × | ×× |
| | 2 | 10% precipitated | + | + | Fair, No symptoms | ..... | × | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | 3 | 10% precipitated | + | + | Good, No symptoms | ..... | ×× | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| | 4 | 10% precipitated | + | + | Good, No symptoms | ..... | ..... | ..... | ..... | ×× | ..... | ×× | ..... | ..... |
| | 5 | 10% precipitated | + | + | Good, No symptoms | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | × |
| | 6 | 10% precipitated | + | — | Good, No symptoms | No lesions found. | | | | | | | | |
| | 7 | 10% precipitated | + | + | Poor, No symptoms | ..... | × | × | ..... | ..... | ..... | × | ..... | ..... |
| | 8 | 10% precipitated | + | — | Fair, No symptoms | No lesions found. | | | | | | | | |
| | 9 | 10% precipitated | — | + | Fair, No symptoms | ..... | ×× | ×× | × | × | ..... | ×× | ..... | ..... |
| | 10 | 10% precipitated | + | — | Fair, No symptoms | No lesions found. | | | | | | | | |
| | 11 | 10% precipitated | + | + | Fair, No symptoms | ..... | × | ×× | ..... | ×× | ..... | ×× | ..... | ..... |

The above table does not include the 123 non-reacting cattle in which no tuberculosis lesions were found.

The autopsy totals of cattle tested intradermally with 10 per cent Koch's Old Tuberculin or 5 to 10 per cent alcoholic precipitated tuberculin are:

| | Number | Per cent |
|---|---|---|
| Number of reacting cattle in which tuberculous lesions were found | 69 | 94.5 |
| Number of reacting cattle in which no tuberculous lesions were found | 4 | 5.5 |
| Total for reacting cattle | 73 | 100.0 |
| Number of non-reacting cattle in which no tuberculous lesions were found | 123 | 95.3 |
| Number of non-reacting cattle in which tuberculous lesions were found | 6 | 4.7 |
| Total for non-reacting cattle | 129 | 100.0 |

## THE LOCAL REACTION TO THE INTRADERMAL INJECTION IN CATTLE

A positive intradermal reaction is indicated by a thickening of the subcaudal fold or by the appearance at the point of injection of a characteristic sensitive swelling varying in size from that of a small pea to that of an orange. The swelling may be either soft and oedematous or hard and inflamed. A recognizable reaction may be present on the sixth hour, but generally the reaction is first clear about the twelfth hour and continues to increase in size until the forty-eighth hour. In some instances we have observed that the early local reactions disappear before the forty-eighth hour, while in others delayed reactions have been noted which did not appear until the nineteenth hour. In order to be certain of every case, observations must be taken at least twice, preferably about the thirty-sixth and seventy-second hours. If only one observation can be made it should be on the seventy-second hour. *Small indurations at the point of inoculation about the size of the head of a parlor match frequently occur in normal non-reacting cattle, but anything larger than this which persists to the seventy-second hour should be considered a positive reaction.*

In recording the reactions, a convenient method for comparison is to describe the size of the swelling as pea size, hazelnut, walnut or hen's egg size. The exact size, if desired, may be measured by means of calipers such as are shown in plate 1, figure 3. Romer and Joseph[43]

consider that a thickening of the skin fold more than three millimeters larger than the thickness previous to injection should be considered a positive reaction. Cases in which the increase in thickness only amounts to three millimeters, they consider doubtful and subject to a retest. In our work, however, we have found the measurement of the swelling was not of much assistance. Experience and practice will enable the operator to judge of the size of the swellings without measuring, although for the sake of accurate records we have made a practice of taking careful measurements.

In judging a local swelling, the observer should depend more upon the shape, appearance, tenseness, sensitiveness and location with respect to the exact point of injection, than upon the actual measurements. Only experience can teach an operator how to be certain of a positive reaction when the local swelling is small. This is especially true when tuberculin containing glycerin has been used.

## THE THERMAL REACTION TO THE INTRADERMAL INJECTION IN CATTLE

Moussu and Mantoux[37] state that no thermal reaction follows their method of performing the test. On the contrary, we have found that tuberculous cattle usually do show a marked temperature reaction when injected intradermally with the dosage and strength of tuberculin recommended by these investigators. Moussu and Mantoux used tuberculin brut (Koch's old tuberculin) diluted with ten volumes of physiological salt solution. Their dose was from $\frac{1}{10}$ to $\frac{1}{5}$ cc.

We have used this kind of tuberculin in testing 207 cattle when frequent temperature readings were taken after the intradermal injection. One hundred and twenty-four showed a local reaction swelling. In 101 of these 124 cases distinct temperature reactions also occurred. Three cows which showed a local, but no thermal reaction, were autopsied and found to be tuberculous. These cases are described in detail later.

The following table of twenty tests selected at random from the 101 cases mentioned above, shows the typical height of the thermal reaction to Moussu and Mantoux's method.

## TABLE 4

TYPICAL CASES SELECTED TO SHOW THAT CATTLE REACT THERMALLY TO THE INTRADERMAL TEST.

| Ear Tag No. | INTRADERMAL TEST RECORD Dose: 1/5 cc. of 10 % solution of Koch's Old Tuberculin. Date: May 20, 1913. Temperatures: Before Injection Min | Before Injection Max. | After Injection 6 hr. | 9 hr. | 12 hr. | 14 hr. | 16 hr. | 18 hr. | 20 hr. | Test Result | Swellings Size and description | SUBCUTANEOUS TEST RECORD Dose: 2 cc. of 10% solution of Koch's Old Tuberculin. Date: May 20, 1913. Temperatures: Before Injection Min. | Before Injection Max. | After Injection 8 hr. | 10 hr. | 12 hr. | 14 hr. | 16 hr. | 18 hr. | 20 hr. | Test Result |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31 | 101.1 | 101.2 | 102.4 | 104.8 | 106.6 | 105.0 | 103.1 | 101.0 | 101.4 | + | 40 mm., orange, hard | 101.1 | 101.4 | 104.6 | 105.0 | 105.9 | 105.4 | 105.1 | 105.6 | 101.7 | + |
| 32 | 100.8 | 101.8 | 102.8 | 104.0 | 103.6 | 103.3 | 102.0 | 101.4 | 100.8 | + | 20 mm., walnut, hard | 101.0 | 101.0 | 102.4 | 103.6 | 103.9 | 104.0 | 102.4 | 101.6 | ..... | + |
| 36 | 101.6 | 103.2 | 103.9 | 104.6 | 104.5 | 105.4 | 104.5 | 104.2 | 100.1 | + | 13 mm., hazelnut, medium | 101.2 | 102.1 | 104.2 | 105.4 | 105.2 | 104.2 | 103.4 | 104.4 | 104.6 | + |
| 46 | 100.6 | 101.0 | 101.8 | 101.4 | 104.2 | 103.6 | 103.2 | 100.0 | 100.7 | + | 15 mm., walnut medium | 100.8 | 101.4 | 101.5 | 104.6 | 104.8 | 103.2 | 101.8 | 103.5 | 102.8 | + |
| 48 | 101.4 | 101.8 | 102.4 | 102.7 | 104.8 | 104.0 | 103.6 | 102.9 | 100.6 | + | 13 mm., hazelnut, medium | 101.6 | 102.7 | 104.3 | 105.8 | 103.6 | 104.4 | 104.6 | 104.8 | 104.3 | + |
| 56 | 101.2 | 101.8 | 103.2 | 106.3 | 105.6 | 105.6 | 104.0 | 102.2 | 101.8 | + | 20 mm., walnut, medium | 101.1 | 101.8 | 103.7 | 104.9 | 105.8 | 103.5 | 103.2 | 102.6 | ..... | + |
| 66 | 100.9 | 102.0 | 103.0 | 105.1 | 106.0 | 103.0 | 102.0 | 101.4 | 100.4 | + | 20 mm., walnut, medium | 100.5 | 101.6 | 103.1 | 105.0 | 105.6 | 104.7 | 104.0 | 104.8 | 103.6 | + |
| 72 | 100.8 | 101.0 | 102.0 | 101.6 | 104.0 | 104.2 | 103.6 | 101.0 | 101.0 | + | 10 mm., pea medium | 100.6 | 101.8 | 101.4 | 102.2 | 104.4 | 104.3 | 103.5 | 104.7 | 102.6 | + |
| 74 | 101.4 | 101.6 | 101.2 | 102.0 | 105.5 | 105.0 | 102.8 | 102.8 | 100.7 | + | 10 mm., pea, hard | 100.6 | 101.6 | 104.6 | 105.0 | 106.0 | 103.0 | 103.2 | 104.4 | 104.0 | + |
| 76 | 101.0 | 101.4 | 102.6 | 105.2 | 105.2 | 105.2 | 104.0 | 103.0 | 101.4 | + | 20 mm., walnut, medium | 101.4 | 101.6 | 105.8 | 105.6 | 103.8 | 102.8 | 102.6 | 103.0 | ..... | + |
| 80 | 101.0 | 102.0 | 104.0 | 103.2 | 102.2 | 101.8 | 100.8 | 100.6 | 100.4 | + | 10 mm., pea, medium | 101.5 | 102.0 | 103.2 | 103.3 | 103.9 | 103.2 | 102.6 | 101.8 | ..... | + |
| 82 | 101.4 | 101.6 | 103.1 | 103.9 | 105.0 | 106.0 | 104.8 | 104.4 | 102.8 | + | 15 mm., walnut, medium | 101.2 | 102.0 | 104.4 | 106.0 | 106.0 | 105.0 | 104.4 | 103.6 | ..... | + |
| 84 | 100.8 | 101.5 | 102.6 | 105.0 | 106.2 | 105.0 | 104.5 | 102.4 | 101.8 | + | 40 mm., orange, hard | 100.8 | 101.7 | 106.1 | 106.2 | 104.0 | 103.0 | 102.3 | 102.0 | ..... | + |
| 85 | 100.6 | 101.4 | 104.0 | 105.5 | 105.6 | 104.6 | 103.8 | 103.1 | 102.8 | + | 25 mm., egg, medium | 101.0 | 101.2 | 105.4 | 103.8 | 102.7 | 100.8 | 101.4 | 100.3 | ..... | + |
| 95 | 101.6 | 101.6 | 102.8 | 101.4 | 106.0 | 104.6 | 104.0 | 102.5 | 101.6 | + | 40 mm., orange, hard | 100.4 | 101.7 | 104.9 | 104.1 | 104.2 | 103.2 | 101.8 | 103.6 | 103.5 | + |
| 97 | 101.6 | 101.6 | 102.0 | 101.4 | 105.6 | 105.6 | 104.0 | 100.6 | 99.9 | + | 10 mm., pea, hard | 101.2 | 101.2 | 101.1 | 102.8 | 104.2 | 104.8 | 103.8 | 102.4 | ..... | + |
| 99 | 100.6 | 101.1 | 103.1 | 104.8 | 107.9 | 105.4 | 104.2 | 101.2 | 100.0 | + | 20 mm., walnut medium | 99.8 | 101.4 | 104.2 | 105.6 | 105.4 | 104.6 | 104.6 | 104.0 | 104.4 | + |
| 103 | 101.8 | 102.5 | 103.1 | 103.3 | 106.6 | 106.2 | 105.8 | 105.4 | 100.1 | + | 13 mm., hazelnut medium | 100.4 | 102.8 | 102.2 | 104.0 | 106.0 | 106.0 | 105.8 | 105.2 | 104.0 | + |
| 113 | 101.3 | 102.0 | 102.5 | 103.2 | 105.4 | 105.1 | 103.6 | 102.4 | 102.0 | + | 20 mm., walnut medium | 101.2 | 101.4 | 102.6 | 104.6 | 105.9 | 103.7 | 102.1 | 102.2 | ..... | + |
| 114 | 100.2 | 101.4 | 104.4 | 104.2 | 102.4 | 102.6 | 102.6 | 102.0 | 101.7 | + | 15 mm., walnut, medium | 100.6 | 103.0 | 105.0 | 104.4 | 102.4 | 101.8 | 101.0 | 99.8 | ..... | + |

**All animals in this table reacted to both tests.**

In six herds where we have applied intradermal tests to cattle temperatures were taken at two-hour intervals from the eighth to the twentieth hour after the intradermal injection, and, in addition, in herd No. 8 from the second to the twentieth hour and in herd No. 20 from the eighth to the twenty-eighth hour.

TABLE 5

SHOWING TESTS IN SIX HERDS IN WHICH THERMAL REACTIONS USUALLY RESULTED FROM AN INTRADERMAL INJECTION

| Herd No. | Total cows tested | Tuberculin used | Number of cattle that reacted locally | Number of cattle that reacted thermally to intradermal injection | Number of cattle that reacted locally but not thermally | Number of cattle that reacted thermally but not locally |
|---|---|---|---|---|---|---|
| 8 | 172 | 10 per cent O. T. | 124 | 102 | 22 | 0 |
| 12 | 21 | 2 per cent precipitated | 1 | 1 | 0 | 0 |
| 11 | 25 | 10 per cent O. T. | 1* | 0 | 1 | 0 |
| 20 | 23 | 10 per cent precipitated | 16 | 16 | 0 | 0 |
| 21 | 4 | 10 per cent precipitated | 1 | 1 | 1 | 0 |
| 22 | 14 | ½ per cent precipitated | 6 | 6 | 0 | 0 |
| 22† | 14 | 10 per cent precipitated | 4 | 4 | 1 | 0 |
| Totals | 273 | | 153 | 130 | 25 | 0 |

* See autopsy notes on cow Peggy, p. 129.

† Retest in three days.

The following table shows the results of tests made on six calves that had been injected with cultures of human tubercle bacilli six weeks previous for the purpose of immunizing them after the method of Pearson and Gilliland:

## TABLE 6

RESULTS OF SUCCESSIVE INTRADERMAL TESTS WITH PRECIPITATED TUBERCULIN ON SIX VACCINATED CALVES

| Calf number | Test No. 1 on July 30, 1913. Dose: 1/3 cc. of 1/2% precipitated tuberculin solution. | | | | | | | | | Test No. 2 on August 5, 1913. Dose: 1/10 cc. of 10% precipitated tuberculin solution. | | | | | | | | | | Summary | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Thermal Observations | | | | | | | Local Observations | | Thermal Observations | | | | | | | Local Observation | | | 1st test | | 2nd test | |
| | Temperature before injection | | Temperature after injection | | | | Result | Size and description of swellings | Result | Temperature before injection | | Temperature after injection | | | | Result | Size and description of swellings | Result | Temperature | Swelling | Temperature | Swelling |
| | Min. | Max. | 8th | 12th | 16th | 20th | | | | Min. | Max. | 8th | 12th | 16th | 20th | | | | | | | | |
| 1 | 102.0 | 102.8 | 102.7 | 104.5 | 106.2 | 104.6 | + | 55 mm., orange, hard | + | 102.4 | 102.6 | 104.5 | 102.9 | 102.8 | 102.2 | + | 20 mm., walnut, soft | + | + | + | + | + |
| 2 | 101.4 | 102.4 | 103.2 | 106.6 | 105.8 | 102.4 | + | 38 mm., orange, hard | + | 101.6 | 102.6 | 105.6 | 103.2 | 101.8 | 101.8 | + | 15 mm., walnut, soft | + | + | + | + | + |
| 3 | 101.4 | 103.6 | 103.6 | 105.6 | 105.6 | 101.8 | + | 20 mm., walnut, hard | + | 102.2 | 102.4 | 104.2 | 102.6 | 102.9 | 102.4 | + | 20 mm., walnut, soft | + | + | + | + | + |
| 4 | 101.6 | 103.2 | 103.2 | 105.4 | 105.4 | 103.4 | + | 30 mm., walnut, hard | + | 101.8 | 103.2 | 103.6 | 102.4 | 102.6 | 102.4 | +? | 16 mm., hazelnut, soft | + | + | + | +? | + |
| 5 | 101.4 | 102.6 | 102.0 | 102.0 | 103.6 | 102.2 | + | 12 mm., hazelnut, soft | + | 102.0 | 102.6 | 103.6 | 101.4 | 101.1 | 101.8 | +? | 12 mm., hazelnut, soft | + | + | + | +? | + |
| 6 | 101.4 | 101.6 | 100.6 | 101.0 | 102.6 | 103.0 | + | 18 mm., walnut, hard | + | 101.0 | 102.0 | 100.8 | 101.2 | 101.0 | 101.6 | — | 20 mm., walnut, soft | + | + | + | — | + |

It would appear from this table that the intradermal test has a slightly depressing effect on the reaction to an intradermal injection seven days later. The reaction swellings are uniformly smaller and the temperature does not rise so high after the second injection. The animals described in Table 4 were presumably healthy calves which on June 12, 1913, had been treated with cultures of human tubercle bacilli, strain Revenel M.

## ACCURACY OF THE INTRADERMAL COMPARED WITH THE SUBCUTANEOUS METHOD

Investigators are so evenly divided on the question of which is the more accurate test that Table 7, showing comparative tests on one thousand cattle, including 326 reactors, is worthy of study in this connection. Moussu and Mantoux[37] in their original work compared the intradermal and subcutaneous tests on seventy reacting animals. They found that the two methods agreed in every case. In most instances they verified their findings by autopsy and concluded that the intradermal equals the subcutaneous test in accuracy. Vallee, Declaire and Herbert[48] tested 521 cattle by both methods. Four hundred and ninety-four reacted to the intradermal and 506 to the subcutaneous; that is twelve cattle with positive thermal reactions gave no intradermal reaction. Ward and Baker[50-51] tested 157 head, using the 10 per cent dilution of Koch's old tuberculin recommended by Moussu and Mantoux.[37] They verified their decisions by autopsy and concluded that the intradermal compares favorably in accuracy with the subcutaneous method. Zschocke[55] tested 300 cattle and found that 85 per cent of known tuberculous cattle reacted to the intradermal test. He considered the neck and tail injections of equal value. Longley[23] and McKenna[26] tested about 1500 cattle, using ½ per cent solutions of precipitated tuberculin, and decided that the intradermal test equals the subcutaneous in accuracy. Romer and Joseph,[43] using 50 per cent tuberculin solutions, found that one out of seventy-nine tuberculous animals failed to react to the intradermal test. Norgaard and Case,[39] after testing several thousand head, decided that the intradermal test was more satisfactory than the subcutaneous and stated that its substitution for the old method was fully warranted. Zwick and Tietze[57] admit no advantage for either the intradermal or

ophthalmic test and have not found them as accurate as the subcutaneous. Tietze[47] finds the intradermal more reliable than the ophthalmic. His conclusion is that the intradermal test is not as accurate as the subcutaneous. Lucky,[24-25] Sheldon,[46] Brown,[2] Kinsley and others in Missouri report, after having tested over thirty thousand head by the intradermal method, that this test is preferable under average conditions when applied by a skilled operator. Hutyra and Marek[15] state that it is desirable in practice where large herds are to be tested to apply a local test first, preferably the intradermal or ophthalmic test, and after the great majority of tuberculous animals have been recognized the remainder of the herd may be subjected to the subcutaneous test. Martin[29] recommends the intradermal test for general practice. Melvin,[32] of the United States Bureau of Animal Industry, reports that the ophthalmic and intradermal tests for the detection of tuberculosis in cattle have received attention. He says: "These methods thus far have not proved sufficiently superior to the subcutaneous injection of tuberculin to warrant their general application in practice, although they are still being tested whenever suitable opportunities are offered. A special preparation known as 'phymatin' has been used in the ophthalmic test and has given better results than the alcoholic-precipitated tuberculin. The ophthalmic and intradermal methods of applying the tuberculin test possess so many advantages, especially in the simplicity of reading the results, that the absolute acceptance of either one would be a great aid in the eradication of tuberculosis." Both methods obviate the laborious operation of taking temperatures repeatedly during the day after the injection and no preliminary temperatures are required. Littlejohn[22] advocates the application of several local tests simultaneously. Lignieres[19] recommends the simultaneous use of the intradermal, ophthalmic and subcutaneous tests. Foth[11] reports that he was able by the aid of the intradermal method to detect only about one-half the tuberculous individuals in Danish quarantine cattle. He states that the subcutaneous injection has a modifying effect on local tests applied simultaneously. Assmann[1] has observed in certain cases, where ophthalmic and thermal reactions occur at the same time, that the local reaction weakened as the thermal reaction gained strength.

The following table of one thousand comparative tests will be of interest to those who desire information concerning the comparative accuracy of the two methods. It will be noted that of the 326 cattle that reacted 35 failed to react to the intradermal method and 44 failed to react to the subcutaneous.

## TABLE 7

COMPARISON OF THE INTRADERMAL AND SUBCUTANEOUS TESTS, USING VARIOUS STRENGTHS OF TUBERCULIN FOR THE INTRADERMAL.*

| Herd No. | Condition | Kind of tuberculin used for intradermal test | Total No. of cattle tested | No. of reactors to intradermal | Questionable intradermal reactions | No. of reactors to subcutaneous * | Questionable subcutaneous reactions | No. reacting positively to intradermal and not to subcutaneous | No. reacting positively to subcutaneous and not to intradermal | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | First time ever tested | 10% Koch's Old | 15 | 14 | 0 | 15 | 0 | 0 | 1 | Subcutaneous test applied 7 days after intradermal. All the cattle were found tuberculous on autopsy. |
| 2 | First time ever tested | 10% Koch's Old | 37 | 3 | 0 | 2 | 0 | 1 | 0 | Tests applied simultaneously. |
| 3 | Had been tested 6 mos. previous | 10% Koch's Old | 209 | 1 | 0 | 1 | 0 | 1 | 1 | Tests applied simultaneously. For autopsy notes see cases Nos. 9, 11, pp. 132, 133. |
| 4 | Had been tested 6 mos. previous | 10% Koch's Old | 91 | 9 | 0 | 8 | 0 | 3 | 2 | Tests applied simultaneously. |
| 5 | First time ever tested | 10% Koch's Old | 20 | 0 | 0 | 0 | 0 | 0 | 0 | Tests applied simultaneously. |
| 6 | First time ever tested | 10% Koch's Old | 15 | 7 | 1 | 3 | 1 | 4 | 0 | The subcutaneous was given 3 days after the intradermal. For autopsies see cases Nos. 3 and 4, p. 130. |
| 7 | First time ever tested | 10% Koch's Old | 21 | 1 | 0 | 1 | 0 | 0 | 0 | Tests applied simultaneously. |
| 8 | First time ever tested | 10% Koch's Old | 172 | 124 | 1 | 124 | 3 | 10 | 10 | Subcutaneous was given 10 days after the intradermal |
| 9 | Tested every 6 mos. for years | 10% Koch's Old | 25 | 1 | 0 | 0 | 0 | 1 | 0 | Tests given simultaneously. For autopsy see case No. 1. |
| 10 | First time ever tested | 35% Koch's Old | 15 | 11 | 2 | 7 | 0 | 4 | 0 | Subcutaneous given 3 days after intradermal. 35% Koch's Old contains too much glycerin. For autopsies see cases Nos. 2, 5 and 6, p. 130. |

* For the subcutaneous test 2 to 4 cc. of Koch's Old Tuberculin 10 per cent was used. Temperatures after injection were taken at two hour intervals from the eighth to the twentieth hour.

TABLE 7—*Continued*

| Herd No. | Condition | Kind of tuberculin used for intradermal test | Total No. of cattle tested | No. of reactors to intradermal | Questionable intradermal reactions | No. of reactors to subcutaneous * | Questionable subcutaneous reactions | No. reacting positively to intradermal and not to subcutaneous | No. reacting positively to subcutaneous and not to intradermal | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | First time ever tested | ½% precipitated | 22 | 9 | 0 | 12 | 0 | 0 | 3 | Tests given simultaneously. |
| 12 | First time ever tested | ½% precipitated | 21 | 7 | 0 | 8 | 0 | 0 | 1 | Tests given simultaneously. (½% tuberculin is too weak.) |
| 12 | Tested 6 weeks previous | 2% precipitated | 21 | 8 | 0 | 8 | 0 | 0 | 0 | Tests given simultaneously. |
| 13 | First time ever tested | 2% precipitated | 35 | 14 | 4 | 13 | 3 | 2 | 1 | Subcutaneous given 3 days after intradermal. For autopsies see cases Nos. 7, 8 and 10. |
| 14 | "Plugging" suspected | 5% precipitated | 16 | 1 | 1 | 2 | 2 | 0 | 1 | Tests given simultaneously. |
| 15 | First time ever tested | 5% precipitated | 3 | 1 | 0 | 1 | 0 | 0 | 0 | Intradermal given 15 days after subcutaneous. |
| 16 | First time ever tested | 5% precipitated | 86 | 43 | 0 | 38 | 0 | 11 | 6 | Tests given simultaneously. |
| 17 | Had been recently tested several times | 10% precipitated | 20 | 8 | 2 | 9 | 1 | 1 | 2 | No subcutaneous injection was made. The thermal reactions resulted entirely from the intradermal injections. |
| 18 | Tested 3 mos. previous | 10% precipitated | 23 | 17 | 1 | 15 | 0 | 3 | 1 | |
| 19 | Tested 6 mos. previous | 10% precipitated | 133 | 12 | 0 | 15 | 4 | 3 | 6 | The subcutaneous test was given 20 days after the intradermal. |
| | Totals | | 1000 | 291 | 12 | 282 | 14 | 44 | 35 | |

*Total reactors to all tests, 326.*

* For the subcutaneous test 2 to 4 cc. of Koch's Old Tuberculin 10 per cent was used. Temperatures after injection were taken at two hour intervals from the eighth to the twentieth hour.

In herds 6, 10 and 13 it is unfair to judge the results from the subcutaneous test without considering the possibility of a modifying effect from the intradermal test just previous. We believe that the above results should be interpreted as indicating that the two tests are about equal in accuracy.

The results reported in tables A, B, and C are all by European observers and the proportion of reacting animals in which no lesions were found is much larger than has been reported by inspectors in the United States. As we do not know under what conditions these tests were performed no comparisons can be made with the results which we have obtained.

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Klimmer and Wolff-Eisner[17] in their handbook of Serumtherapie and Serumdiagnosis have published the following tables which are of interest in a consideration of the intradermal method. It is possible that some of the figures in these tables were misprints, as the additions and percentages do not check in all cases.

TABLE A

INTRADERMAL TESTS

| Veterinarian | Kind of tuberculin | Tuberculous animals | | | Animals in which no lesions were found on slaughter | | |
|---|---|---|---|---|---|---|---|
| | | No. tested | Reacted No. | Reacted Per cent | No. tested | Reacted No. | Reacted Per cent |
| Assman[1] | Phymatin | 40 | 29 | 72 | 11 | 5 | 45 |
| Foth[11] | Bovotuberkulol 25% | 11 | 5 | 45 | 4 | 0 | 0 |
| | Bovotuberkulol 50% | 15 | 7 | 48 | 20 | 1 | 5 |
| | Old tuberculin (Höchst) 100% | 15 | 8 | 52 | 45 | 13 | 29 |
| Zschocke[55] | Phymatin 20% | 46 | 39 | 84 | 53 | 11 | 21 |
| | Phymatin 50% | 40 | 23 | 57 | 21 | 1 | 5 |
| | Phymatin (on swine) | 14 | 13 | 93 | 82 | 1 | 1 |
| | Bovotuberkulol 20% | 16 | 9 | 56 | 21 | 7 | 33 |
| | Bovotuberkulol (on swine) | 1 | 1 | 100 | 14 | 0 | 0 |
| | Tuberkulin (Marburg) 20% | 4 | 1 | 25 | 9 | 0 | 0 |
| | Tuberkulin (Marburg) 50% | 18 | 9 | 50 | 23 | 7 | 30 |
| | Tuberkulin (on swine) | 1 | 1 | 100 | 23 | 0 | 0 |
| Martin[29] | Tuberkulin (on swine) 50% | 10 | 10 | 100 | 93 | 0 | 0 |
| | Tuberkulin (on cattle) 50% | 33 | 33 | 100 | 17 | 1 | 6 |
| Joseph[16] | Tuberkulin (Marburg) | 77 | 76 | 98 | 49 | 2 | 4.1 |
| Total cattle | | 315 | 249 | 79 | 252 | 47 | 19 |
| Total swine | | 26 | 25 | 96 | 212 | 2 | 1 |

TABLE B

RESULTS OF VARIOUS FORMS OF THE TUBERCULIN TEST ON TUBERCULOUS CATTLE

| | | | |
|---|---|---|---|
| A positive cutaneous | reaction occurred in | 39 out of 141 | tuberculous cattle or 28% |
| A positive dermal | reaction occurred in | 38 out of 143 | tuberculous cattle or 27% |
| A positive intradermal | reaction occurred in | 249 out of 315 | tuberculous cattle or 79% |
| A positive vaginal | reaction occurred in | 51 out of 66 | tuberculous cattle or 77% |

TABLE C

RESULTS OF VARIOUS FORMS OF THE TUBERCULIN TEST ON CATTLE IN WHICH NO LESIONS WERE FOUND ON SLAUGHTER

| | | | |
|---|---|---|---|
| A positive cutaneous | reaction occurred in | 6 out of 125 | cattle or 5% |
| A positive dermal | reaction occurred in | 3 out of 65 | cattle or 5% |
| A positive intradermal | reaction occurred in | 47 out of 252 | cattle or 19% |
| A positive vaginal | reaction occurred in | 3 out of 11 | cattle or 27% |

## RESULTS OF RETESTS

On retesting by any form of the tuberculin test, a badly infected herd, from which all the reacting cattle have been removed, it will usually be found that from 1 to 30 per cent will react. This is not necessarily due to the failure of the previous test, because the cattle may in the meantime have become infected from contaminated pastures or other sources.

Another reason for the reaction of such cattle on retest is the fact that cattle often do not react during the incubation of tuberculosis or while the disease is latent and the lesions encapsulated. In a badly infected herd many animals may be so recently infected that sensitiveness to tuberculin has not developed. In tuberculosis this period of incubation is variable. In some cases the disease probably begins to progress on the day of infection; in others the germs may be lodged in the tissues for a long time before lesions actually develop.

The arrest of the disease and encapsulation of the lesions is of frequent occurrence in the tuberculous cattle. This accounts for the fact that cows which have reacted occasionally fail to react when subsequently tested. Later the disease may start up and then, on a third test, the animals may again react. The commission appointed by the American Veterinary Medical Association have recognized these facts in their recommendation that herds over 50 per cent of which give positive reactions be handled, as far as eradication of the disease is concerned, as though all the herd had reacted.

The well-known fact that animals in advanced stages of the disease frequently do not react applies equally to the intradermal and subcutaneous methods, but from our observations we think the former will detect more arrested or latent cases. The results in retesting compare favorably with those we have obtained with the subcutaneous method under similar conditions. The following data showing the results of retests is typical of what is to be expected.

### TESTS FOR DAIRY COMPANY B

Sept. and Oct., 1913. Tested by the intradermal method, 2184 cattle, 775 reacted, 35.5 per cent. (Three hundred of the non-reactors were segregated on one ranch and four months later 228 of them were retested; 176 of the reacting cattle were also retested in four months.)

Feb., 1913. Retested 228 non-reacting cattle, 46 reacted, 20.2 per cent.

Feb., 1913. Retested 176 reacting cattle, 173 reacted, 98.3 per cent.

Following are the results of frequent subcutaneous tests in three dairies:

DAIRY No. 1.

| | No. of cows tested | No. condemned | Per cent |
|---|---|---|---|
| January 5, 1905 | 77 | 14 | 18.3 |
| March 12, 1906 | 62 | 2 | 3.2 |
| September 29, 1906 | 83 | 6 | 7.2 |
| September 14, 1907 | 144 | 32 | 22.2 |
| January 29, 1908 | 130 | 22 | 16.9 |
| August 12, 1908 | 128 | 4 | 3.1 |
| April and September, 1909 | 125 | 2 | 1.6 |
| January 30, 1910 | 114 | 7 | 6.1 |
| August 1, 1910 | 99 | 4 | 4.0 |
| March 21, 1911 | 118 | 4 | 3.4 |
| Purchases to June, 1910 | 342 | 84 | 24.5 |
| Purchases since June, 1910 | 87 | 3 | 3.4 |
| Total number of cattle tested | | | 506 |
| Total number condemned | | | 184 |
| Per cent condemned | | | 36.4 |
| Total number of tests, including retests | | | 1,509 |

DAIRY No. 2

| | No. of cows tested | No. condemned | Per cent |
|---|---|---|---|
| February, 1908 | 196 | 110 | 56.1 |
| February, 1909 | 189 | 13 | 6.9 |
| November, 1909 | 176 | 37 | 21.0 |
| June, 1910 | 246 | 18 | 7.3 |
| February 15, 1911 | 208 | 19 | 9.1 |
| Purchases to June, 1910 | 385 | 135 | 35.1 |
| Purchases since June, 1910 | 14 | ..... | ..... |
| Total number of cows tested | | | 595 |
| Total number condemned | | | 332 |
| Per cent condemned | | | 55.8 |
| Total number of tests, including retests | | | 1,414 |

DAIRY No. 3

| | No. of cows tested | No. condemned | Per cent |
|---|---|---|---|
| November, 1908 | 70 | 12 | 17.1 |
| April, 1909 | 57 | 9 | 15.8 |
| November, 1909 | 73 | 4 | 5.5 |
| May, 1910 | 138 | 2 | 1.5 |
| November, 1910 | 198 | 6 | 3.0 |
| Purchases to June, 1910 | 203 | 5 | 2.5 |
| Purchases since June, 1910 | 320 | 8 | 2.5 |
| Total number of cows tested | | | 593 |
| Total number condemned | | | 46 |
| Per cent condemned | | | 7.8 |
| Total number of tests, including retests | | | 1,059 |

In the last three dairies the reacting cattle were at once removed and the barns were frequently disinfected. Additions to the herd were non-reactors selected chiefly from infected herds. In the case of the cattle belonging to Dairy Company B the non-reacting cattle were separated from the reacting, but thorough disinfection was impossible. Since the conditions in the various dairies differed materially, no comparisons between the intradermal and subcutaneous tests are justified.

## DESCRIPTION OF CASES WHICH REACTED TO THE INTRADERMAL BUT DID NOT REACT TO THE SUBCUTANEOUS TEST

The following detailed history of ten cows which reacted to the intradermal but not to the subcutaneous test is submitted as proof that cattle, having latent, slight or inactive lesions of tuberculosis, may fail to react to the subcutaneous test, but may react to the intradermal.

Except when otherwise stated, all tests in these cases were made with Koch's old tuberculin, dilution 1 to 10 of physiological salt solution. The dose for the intradermal tests was 1/5 cc. The dose for the subcutaneous tests varied from 2 to 4 cc.

**COW 1.** Peggy. Grade Holstein. Good physical condition throughout the time she was under observation.

Oct. 10, 1911. Tested by subcutaneous method. **No reaction.**

Mar. 2, 1912. Tested simultaneously by the subcutaneous and intradermal methods. **No thermal reaction to the subcutaneous. Strong reaction to the intradermal.**

Apr. 2, 1912. Tested by the intradermal method. **Strong reaction.**

July 20, 1912. Tested by the subcutaneous method. **No reaction.**

Oct. 4, 1912. Tested by the subcutaneous method. **No reaction.**

Jan. 1, 1913. Tested by the intradermal method. **Strong reaction.**

Mar. 8, 1913. Tested simultaneously by the subcutaneous and intradermal methods. **No thermal reaction to the subcutaneous. Slight reaction to the intradermal.**

July 10, 1913. Tested by the intradermal method, using 1/5 cc. of 10 per cent solution of purified tuberculin. **Slight reaction.**

July 12, 1913. This cow was slaughtered for beef under municipal inspection. One of the retropharyngeal lymph nodes contained a tuberculous nodule five millimeters in diameter with a wall one millimeter thick composed of greyish connective tissue-like substance. In the center was a small amount of caseous yellow material, partially calcified. In one of the mesenteric lymph nodes a lesion very similar in size and appearance was found. No other lesions were discovered. A guinea pig was inoculated with the tissue and on autopsy August 13, 1913, was found to be extensively tuberculous.

**COW 2.** Ear tag No. 1649. Fair physical condition.

May 6, 1913. Tested by intradermal method. 35 per cent O. T. tuberculin. **Positive reaction.**

May 8, 1913. Tested by subcutaneous method. **No reaction.**

June 6, 1913. Tested by ophthalmic method. **No reaction.**

June 23, 1913. Tested by ophthalmic method. 2 per cent purified tuberculin. **No reaction.**

June 26, 1913. Tested by the intradermal method. 1/2 per cent purified tuberculin. **Positive reaction.**

COW 2—(*Continued*).

June 29, 1913. Tested by the intradermal method. 2 per cent purified tuberculin. **Positive reaction.**

July 10, 1913. Tested by the intradermal method. 10 per cent purified tuberculin. **Positive reaction.**

July 12, 1913. Killed for beef under federal inspection. Four tuberculous nodules similar in appearance to those in Cow 1 (Peggy) were found in the bronchial lymph nodes. No other tuberculous lesions were discovered.

COW 3. Ear tag No. 6. Aged, fair physical condition.

May 6, 1913. Tested by intradermal method. **Positive reaction.**

May 8, 1913. Tested by subcutaneous method. **No reaction.**

June 6, 1913. Tested by the ophthalmic method. **Positive reaction.**

June 23, 1913. Tested by ophthalmic method. 2 per cent purified tuberculin. **No reaction.**

June 26, 1913. Tested by intradermal method. ½ per cent purified tuberculin. **Positive reaction.**

June 29, 1913. Tested by intradermal method. 2 per cent purified tuberculin. **No reaction.**

July 10, 1913. Tested by intradermal method. 10 per cent purified tuberculin. **Positive reaction.**

July 12, 1913. Killed for beef under municipal inspection. The anterior and posterior mediastinal lymph nodes were enlarged to three times normal size and contained dry calcareous and fibrous tuberculous lesions apparently inactive and of long standing. No other lesions were found.

COW 4. Ear tag No. 1219.

May 6, 1913. Tested by intradermal method. **Positive reaction.**

May 8, 1913. Tested by subcutaneous method. **No reaction.**

June 6, 1913. Tested by ophthalmic method. **Positive reaction.**

June 23, 1913. Tested by ophthalmic method. 2 per cent purified tuberculin. **No reaction.**

June 26, 1913. Tested by intradermal method. ½ per cent purified tuberculin. **Positive reaction.**

June 29, 1913. Tested by intradermal method. 2 per cent purified tuberculin. **Positive reaction.**

July 10, 1913. Tested by intradermal method. 10 per cent purified tuberculin. **Positive reaction.**

July 12, 1913. Killed for beef under municipal inspection. Acute lesions of tuberculosis involving both anterior lobes of the lungs and the mediastinal and bronchial lymph nodes.

COW 5. Ear tag No. 1206. Good physical condition.

May 6, 1913. Tested by intradermal method. 35 per cent O. T. tuberculin. **Strong positive reaction.**

May 8, 1913. Tested by subcutaneous method. **No reaction.**

June 6, 1913. Tested by ophthalmic method. **No reaction.**

June 23, 1913. Tested by ophthalmic method. 2 per cent purified tuberculin. No reaction.

**COW** 5—(*Continued*).

June 26, 1913. Tested by intradermal method. ½ per cent purified tuberculin. **No reaction.**

June 29, 1913. Tested by intradermal method. 2 per cent purified tuberculin. **Positive reaction.**

July 10, 1913. Tested by intradermal method. 10 per cent purified tuberculin. **Positive reaction.**

July 12, 1913. Killed for beef under municipal inspection. No tuberculous lesions were found. An unusually careful search was made from a meat inspection standpoint, but it was impracticable to strip the meat from the bones and search the interior of the bones and joints and certain other places where small tuberculous lesions might have existed.

**COW** 6. Ear tag No. 1218.

May 6, 1913. Tested by intradermal method. 35 per cent O. T. tuberculin. **Positive reaction.**

May 8, 1913. Tested by subcutaneous method. **No reaction.**

June 6, 1913. Tested by ophthalmic method. **No reaction.**

June 23, 1913. Tested by ophthalmic method. 2 per cent purified tuberculin. **No reaction.**

June 26, 1913. Tested by intradermal method. ½ per cent purified tuberculin. **Positive reaction.**

June 29, 1913. Tested by intradermal method. 2 per cent purified tuberculin. **Positive reaction.**

July 10, 1913. Tested by intradermal method. 10 per cent purified tuberculin. **Positive reaction.**

July 12, 1913. Killed for beef under municipal inspection. Soft caseous tuberculous lesions in the liver and between the liver and the diaphragm. One mesenteric lymph node was caseous.

**COW** 7. Ear tag No. 68. Fair physical condition.

May 6, 1913. Tested by intradermal method. 2 per cent purified tuberculin. **Positive reaction.**

May 8, 1913. Tested by subcutaneous method. 2 per cent purified tuberculin. **No reaction.**

June 6, 1913. Tested by ophthalmic method. 2 per cent purified tuberculin. **No reaction.**

June 23, 1913. Tested by ophthalmic method. 2 per cent purified tuberculin. **No reaction.**

June 26, 1913. Tested by intradermal method. ½ per cent purified tuberculin. **Positive reaction.**

June 29, 1913. Tested by intradermal method. 2 per cent purified tuberculin. **Positive reaction.**

July 10, 1913. Tested by intradermal method. 10 per cent purified tuberculin. **Positive reaction.**

July 12, 1913. Killed for beef under federal inspection. Tuberculous lesions were present in the anterior lobes of both lungs and in the bronchial and retropharyngeal lymph nodes.

**COW 8.** Ear tag No. 1213.

May 6, 1913. Tested by intradermal method. **Positive reaction.**

May 8, 1913. Tested by subcutaneous method. **No reaction.**

June 6, 1913. Tested by ophthalmic method. **Positive reaction.**

June 23, 1913. Tested by ophthalmic method. 2 per cent purified tuberculin. **No reaction.**

June 26, 1913. Tested by intradermal method. ½ per cent purified tuberculin. **Positive reaction.**

June 29, 1913. Tested by intradermal method. 2 per cent purified tuberculin. **No reaction.**

July 10, 1913. Tested by intradermal method. 10 per cent purified tuberculin. **Positive reaction.**

July 12, 1913. Killed for beef under municipal inspection. Two small tuberculous nodules in the liver, each about 1 cm. in diameter, having firm fibrous walls 1 mm. in thickness. Contents yellow, firm, sprinkled with points of deeper yellow color, calcification was not present and the tissue was not entirely broken down.

**COW 9.** Ear tag No. 1638.

Jan. 14, 1912. Tested by subcutaneous method. **No reaction.**

June 6, 1912. Tested by subcutaneous method. **No reaction.**

Jan. 3, 1913. Tested by subcutaneous method. **No reaction.**

June 6, 1913. Tested by subcutaneous method. **No reaction.**
Tested by intradermal method. **Strong reaction.**

July 7, 1913. Autopsied. In the mediastinal lymph nodes were two tuberculous lesions each about two-thirds the size of the fist, encapsulated and partially liquified. In the mesenteric lymph node was a soft caseous tuberculous lesion two centimeters in diameter.

**COW 10.** Ear tag No. 1220. Fine physical condition throughout the tests.

May 6, 1913. Tested by intradermal method. 2 per cent purified tuberculin. **Positive reaction.**

May 8, 1913. Tested by subcutaneous method. **Positive reaction.**

June 4, 1913. Tested by ophthalmic method. **Positive reaction.**

Aug. 20, 1913. Tested simultaneously by the subcutaneous and intradermal methods. **Positive reaction to both tests.**

Oct. 24, 1913. Tested by ophthalmic method. **Positive reaction.**

Oct. 26, 1913. Tested by ophthalmic method. **Positive reaction.**

Dec. 4, 1913. Tested simultaneously by the ophthalmic, subcutaneous and intradermal methods. **Positive reactions to the ophthalmic and intradermal tests, no reaction to the subcutaneous method.**

Dec. 5, 1913. Autopsied. Two very small tuberculous lesions in the lymph nodes on rumen.

Zwick and Tietze[27] state that the intradermal and ophthalmic tuberculin tests are of no value in distinguishing the progressive cases from those having arrested latent or healed lesions. We agree in this, in that we have not been able to apply in a practical way the

different forms of the tuberculin test to the classification of tuberculous cattle according to the extent or activity of their lesions. However, the cases which react locally to the intradermal test, but which fail to react thermally either to the intradermal or subcutaneous injections, have usually been found on autopsy to contain small encapsulated lesions.

## DISCUSSION OF CASES WHICH REACTED THERMALLY TO THE SUBCUTANEOUS BUT SHOWED NO LOCAL REACTION TO THE INTRADERMAL TEST

We have observed thirty-five cases which showed a thermal reaction to the subcutaneous method but no local reaction to the intradermal method. This should be considered in judging the comparative value of the intradermal test. Fourteen of the above mentioned thirty-five cows were tested by both methods on the same day. One of these was afterward autopsied and found to contain a few active tuberculous lesions. Following is her history:

**COW 11.** Ear tag No. 2187.

Jan. 5, 1913. Tested by subcutaneous method. **No reaction.**

June 27, 1913. Tested by subcutaneous method. **Positive reaction.**
Tested by intradermal method. **No reaction.**

July 7, 1913. Autopsied. The lungs contained one tuberculous lesion the size of a half dollar, encapsulate with caseous center. One bronchial gland contained a calcified tuberculous lesion five millimeters in diameter. The liver contained two well-healed lesions, averaging one centimeter in diameter.

The failure of this and thirty-four other cows to react locally might be accounted for by the theory that a local reaction is weakened, or disappears, when it occurs simultaneously with a temperature reaction. The observations of Foth[11] and Assmann[1] already quoted are of interest in this connection. However, we have observed so many instances in which marked thermal and intradermal reactions occurred simultaneously from an intradermal injection that more evidence is desirable before accepting this theory. We are inclined to attribute the failure of the intradermal test to the well-supported theory that no form of the tuberculin test will detect every case of tuberculosis in cattle, and that the maximum number of reactors can only be determined by applying the various tests simultaneously, or the local tests first and following them by the subcutaneous method

after an interval of at least seven days. Assmann[1] has pointed out that the proportion of questionable, or faulty, diagnoses amount to over 13 per cent for the thermal, while he admits only 9 per cent of failures with the ophthalmic test.

Hastings[14] states that probably in 15 per cent of the animals examined in badly infected herds the subcutaneous test is in error. By far the greater number of errors is due to the non-reaction of tubercular animals. Both the thermal and intradermal tests occasionally fail to produce reactions in tuberculous cattle under circumstances that exclude an explanation on the ground that the disease was either latent, or so advanced that the cattle would not react. The possibility of the animals having been rendered insusceptible by previous injections of tuberculin can also be eliminated.

## THE COMPARATIVE ADVANTAGES OF THE INTRADERMAL AND OPHTHALMIC METHODS IN TESTING CATTLE

Six state veterinarians have recently written us that they consider the intradermal method preferable to the ophthalmic. Hutyra and Marek[15] also indicate a preference for the intradermal over the ophthalmic. Our data on this point are rather meager. In tests on known tuberculous animals with 10 per cent solutions of Koch's old tuberculin our results were unsatisfactory, being negative in all instances. Five per cent solutions of precipitated tuberculin, however, proved very satisfactory. In 139 cattle known to be reactors to the subcutaneous or intradermal methods, when tested by the ophthalmic method, using this tuberculin, we produced pronounced conjunctival reactions in every case. In one instance a cow reacted to the ophthalmic test, but failed to react to either the intradermal or

* The ophthalmic tuberculin test as first applied to cattle in 1907 did not give very uniform results, probably because it was made either with a weak solution or with tuberculin diluted with irritating solutions of glycerin, trikresol, or phenol. Recent observations by Foth[11] and others have shown that 5 per cent solutions of dry tuberculin give very good results in this test.

*Technic of the Ophthalmic Test.*—An assistant should grasp the animal by the nose and turn the head at an angle so that the operator may drop one or two drops of the tuberculin directly upon the eyeball. A small hypodermic syringe is more suitable for this purpose than a medicine dropper. The closed eye is then slightly massaged for several seconds. In cattle the reaction usually sets in by the eighth hour. It manifests itself by a watering of the eye, reddening of the conjunctiva and dropsical swelling of the lid. Later a purulent exudate accumulates at the inner corner of the eye and usually runs down the face. This sometimes dries up and drops off in a few hours, so that the evidences of the reaction may entirely disappear in twenty-four hours, although occasionally they can be seen for several days. Although the results of the test are usually apparent by the twelfth hour, additional observations should be made on the eighteenth and twenty-fourth hours to detect any delayed reactions.

subcutaneous tests. On autopsy this cow proved tuberculous. In testing range cattle we have found it easier to apply the intradermal than the ophthalmic test. The eye test is more reliable than either the intradermal or subcutaneous methods for testing animals which have been recently injected with tuberculin. The test can be repeatedly applied without injury to the eye. Its frequent repetition does not injure its accuracy. When given simultaneously with, or subsequent to, either the intradermal or subcutaneous test it may occasionally assist in deciding doubtful reactions. Since the reaction usually occurs by the eighth hour, it is sometimes found preferable in veterinary practice to use this method when quick results are necessary. Our attempts to use the ophthalmic method in the routine testing of dairy cows have failed to give satisfaction. In one instance when the test was applied to a dairy of eighty-six cows, known to include at least forty reacting animals, the rain washed out or obscured all but one conjunctival reaction. In other instances we have observed that the exposure to bright sunshine and wind has caused equally unsatisfactory results. The test is only satisfactory when the cattle can be kept tied or confined in stanchions under shelter for a period of at least sixteen hours, except in the case of animals which show a reaction before that time. The cattle should be fed only on concentrates, or finely chopped hay. We have verified the observation of White and McCampbell that it is advisable not to feed long hay while the reaction is developing on account of the possibility of wiping off the exudate. Klimmer,[17] Assman,[1] Melvin,[32] Konge[18] and others have reported excellent results with the ophthalmic test when using a preparation known as phymatin. In testing twenty-three tuberculous cattle with this preparation we have obtained positive reactions in every case. Phymatin will also produce reactions when injected intradermally.

### USE OF THE INTRADERMAL TUBERCULIN TEST ON SWINE

At the University of California Hog Serum Laboratory the intradermal test is used as a matter of routine on all hogs purchased. The test is very satisfactory, the reactions usually being larger in size than in cattle. A dose of at least $\frac{1}{5}$ cc. should be used. We are undecided as to the best place to make the injection. Injections into the skin at the edge of the ear are very easily seen. However, when the injection is made at the base of the ear the swellings are often larger. Tuberculous hogs often show a thermal as well as a local reaction to $\frac{1}{5}$ cc. doses of a 10 per cent solution of alcoholic precipitated tuberculin.

Following is a statement of certain tests made by Dr. J. F. Mitchell at the University of California Hog Serum Laboratory: Sixty-nine hogs were tested by the intradermal method, using 10 per cent Koch's Old Tuberculin, and fifteen reacted. Three days later the ophthalmic test was administered, using the same kind of tuberculin. No eye reactions occurred, except possibly in one case, which showed a very slight discharge from one eye. Twenty days later sixty-two of these hogs, including the fifteen reactors, were again tested by the intradermal method and twenty reacted. We used 2 per cent precipitated tuberculin on nineteen of these, including four that had previously reacted. Six reactions resulted with this tuberculin including the four hogs which had reacted at the previous test. Ten per cent Koch's Old Tuberculin was used on the remaining forty-three, including nine hogs that had reacted at the previous test, and fourteen of the forty-three reacted, including the nine that had previously reacted.

Fourteen days later eighteen of the reacting hogs were given the ophthalmic test, using 5 per cent precipitated tuberculin, and seven of these showed a very slight yellowish discharge in the eye injected, but not enough to be of any great diagnostic value. Nine of the reactors have been killed, and in one of them we failed to find lesions; the others were tuberculous. In only one case was the entire carcass condemned for tuberculosis.

## CONDITIONS UNDER WHICH THE INTRADERMAL TEST IS PREFERABLE

Since the reaction to tuberculin when injected by the intradermal method depends on a swelling at the point of injection and not on thermal manifestations, it is to be preferred to the subcutaneous injection under all conditions that are liable to modify the tuberculin temperature curve. In testing wild range cattle, even if it is possible to restrain them, no reliance can be placed on the reaction as shown by the tuberculin temperature curve.

In calves under six months of age there is liable to be a difference of two or more degrees in the normal temperature on two consecutive days. The temperature of some cows is easily influenced by variations in the weather and also by changes in handling and feeding. We deem it advisable to test by the intradermal method if the temperature of the air where the cattle are confined exceeds 100 degrees F. or in cold weather if the animals will be compelled to stand in a draught. Cattle from a long journey by road or rail are apt to have an abnormal temperature.

If an animal reacts locally there is a record left at the point of injection in the form of a swelling, this swelling being discernible in some instances three weeks after injection.

The local intradermal reaction is not affected by advanced pregnancy, recent parturition or the period estrum. We hesitate to mention this as an advantage over the subcutaneous method, however, for in our experience in testing numerous cows in this condition we have not observed that the reliability of the subcutaneous test was affected.

Although we have reason to believe that the intradermal method modifies to some extent the results of a subsequently performed subcutaneous test, its effect is certainly not so pronounced as a previous subcutaneous test. When cattle are to be retested a weak solution (½ per cent precipitated tuberculin) can be used. We believe that the intradermal test can always be satisfactorily substituted for the subcutaneous by an experienced operator, provided a strong tuberculin (5 per cent or stronger solution of precipitated) is used for the intradermal injection and daily observations on the swellings are continued to the ninetieth hour. In fact, we are convinced that when performed in this way on large, badly infected herds more tubercular animals will be detected than when dependence is placed on temperature reaction alone.

It is reported that in certain pure bred herds where the owners permit prospective purchasers to apply the tuberculin test the animals sometimes receive several tests a year. The substitution of either the intradermal or ophthalmic test, preferably the latter, would be desirable in such herds, because these tests, not being so liable to render the infected animals insensitive to tuberculin, would have the advantage.

## CONDITIONS UNDER WHICH THE INTRADERMAL TEST IS UNRELIABLE

Tuberculous cattle that have been recently injected with tuberculin frequently do not respond to the intradermal test. The method does not seem to have much advantage over the subcutaneous in this respect, and is inferior to the ophthalmic for retesting. Repeated intradermal tests render tuberculous cattle unresponsive to either the subcutaneous or intradermal methods.

In the hands of an inexperienced man the intradermal is not so reliable as the subcutaneous or ophthalmic methods. Even a graduate

veterinarian who has not received special instruction or at least perfected himself in the interpretation of the local swellings by several autopsies or observations of this test when administered in conjunction with the usual subcutaneous method, in our opinion is not capable of securing good results.

Since small doses are used in the intradermal method it is of the highest importance that the tuberculin be of a high standard of potency. It must be sterile and free from glycerin. It must be administered in a clean and skillful manner. A bungling operator, by introducing the needle several times may cause traumatic injuries which may have the appearance of reactions. Observations on the reactions should be continued until the seventy-second hour. Under no circumstances can this test be finished as quickly as the other methods. If pressed for time the veterinarian must depend on the ophthalmic and subcutaneous method. Dr. Law in his treatise on veterinary medicine, mentioned seventeen conditions under which he believes the subcutaneous method to be unreliable, but in most instances these do not apply to the intradermal method. In competent hands this method has the advantage over either the subcutaneous or ophthalmic under average California conditions.

Cattle in a very thin, starved condition are not suitable subjects for any form of the tuberculin test. In testing some dry dairy cows that had been turned out on scanty pasture, we observed that several known tuberculous animals failed to react to the subcutaneous test. The preliminary results of experiments which we are making on some stock indicated that during the winter, when the feed is poor and the cattle are somewhat reduced in flesh, their sensitiveness to tuberculin is not as pronounced as when they are in prime condition.

## ANSWERS TO CERTAIN OBJECTIONS TO THE INTRADERMAL METHOD

An argument that has been advanced against the use of the intradermal method for official tuberculin testing is that tabulated records of the test results cannot be made. Would not a tabulation of the measurements of the swellings, together with notes on their appearance and sensitiveness, constitute an acceptable test record? Vallee[49] suggests that a series of observations be expressed graphically. An advantage of the intradermal test in this respect is that reacting swellings usually persist for several days and in some cases for weeks. The presence or absence of such a swelling in case of dispute would constitute evidence which would add to the value of the tuberculin test record. We have observed that some cattle which reacted to the

intradermal showed a return of the local reaction when retested by the subcutaneous method. Occassionally this recurring local reaction has exceeded the original in size. This return of the subcaudal swelling after the injection of tuberculin subcutaneously in the neck has been observed even after an interval between tests of three months.

Another objection is that it requires an expert and experienced man to use the intradermal method successfully. We admit that the test demands some experience, but have pointed out that any practitioner can gain that experience while applying the usual subcutaneous method. On the other hand, it is not a test which can be as readily used by the layman as the subcutaneous method. We mention this latter fact, knowing that it may appeal to many as a favorable argument, although it is to be regretted that there has not as yet been perfected a test so simple and accurate that any dairyman can use it on his own herd. We believe that the ophthalmic comes nearer to this than either the intradermal or subcutaneous method.

The very just objection is made that as yet we do not know whether the test is as accurate as the subcutaneous method. More data are needed on this point. Comparison should be made by autopsy, and I regret that in California we have been able to follow up with autopsies only 341 cases out of 4001 tested. To be of any value such autopsies should be made on the non-reacting as well as reacting animals. Most tests that have been recently made to determine the value of the intradermal have included the autopsy of both the reacting and non-reacting animals. The intradermal test is so easy to apply that it would be possible for federal or state officials to arrange with abattoirs to apply the test to thousands of head and follow them to the killing floor. Titze[47] has concluded after a study of the results of the intradermal and ophthalmic tests in Germany that these methods are not equal in accuracy to the subcutaneous. Quoting statistics of the U. S. Bureau of Animal Industry,[31] he assumes that it is possible to make a sure diagnosis by the subcutaneous method in more than 97 per cent of tuberculous cattle. Hastings[14] has pointed out the fallacy of such deductions. Although 98.93 per cent of the since no autopsies were made on them. We believe that the sub- under supervision had tuberculous lesions, it is not known what proportion of the 363,008 non-reacting cattle really had tuberculosis. 24.784 reacting cattle reported by Melvin[31] as having been autopsied cutaneous test as ordinarily performed on large numbers of cattle will fail to detect tuberculosis in at least 10 per cent of the occult cases. Wills[54] found with the subcutaneous test that over 20 per cent of the thermal reactions in seventy-two tuberculous cattle occurred

subsequent to the eighteenth hour after injection. Even if it is eventually found that the intradermal test fails to detect tuberculosis in 10 or 15 per cent of occult cases, we would still consider it as efficient as the subcutaneous method.

The strongest objection to the intradermal test seems to be that as yet a standard tuberculin for this test has not been perfected. With the six leading biological houses of this country each putting out a different kind of "intradermal tuberculin," some of which, to say the least, are unsuitable for the purpose, uniform results are impossible.

We have advocated in this paper the combination of the intradermal and ophthalmic with the subcutaneous method. The objection is that this requires too much time and work. This is the crux of the whole bovine tuberculosis situation. Such objections are made by practitioners who are willing to slight their work in order to obtain an easy fee. In case it is impossible to perform the subcutaneous test thoroughly, the intradermal should certainly be used. Schnürer[45] has pointed out that the combination of several tests increases the certainty of the results. The combined tests add accuracy by confirming the many questionable reactions that occur and by detecting tuberculous cows that react to but one test. At present it would be a backward step to abandon the subcutaneous method for official work. Combining the two tests gives time for physical examination, in which more thoroughness is sadly needed in this state.

## SUMMARY

In all, 4926 intradermal tests have been made on 4001 cattle, 1614 of which reacted, and there has been an opportunity to check these results by autopsies in 341 cases and by the discovery of lesions on physical examination in 54 additional cases.

To 291 cattle that reacted to the intradermal test the subcutaneous test was subsequently or simultaneously applied, and 282 cattle reacted. Forty-four cattle with a positive intradermal reaction gave no thermal reaction to the subcutaneous test. It was possible to autopsy only ten of these which failed to react to the subcutaneous method, but in nine of the ten tuberculous lesions were found. Thirty-five cattle which failed to react to the intradermal test subsequently reacted to the subcutaneous test. Two of these cows which reacted to the subcutaneous method, but showed no swelling at the point of intradermal injection, were found on autopsy to be tuberculous.

Cattle which react to the intradermal test with local swelling usually have also a thermal reaction similar to that produced by the ordinary subcutaneous injection.

The intradermal test is unreliable when applied a few days after a subcutaneous injection. The time limits under which this holds true have not been determined.

The intradermal test appears to have some modifying effect on a subsequent test by either the intradermal or subcutaneous methods, but this is not so pronounced as that produced by the usual subcutaneous injection.

The thermal reaction which accompanies the intradermal injection usually subsides in twenty hours, but it seems desirable not to apply the subcutaneous test for several days after the intradermal. The longer the interval the better.

The subcaudal fold is a more suitable point for the intradermal injection than the neck.

Our results with Koch's Old Tuberculin in 10 per cent solutions and with alcoholic precipitated tuberculin in ½ per cent solutions compare favorably in accuracy with the usual subcutaneous method. A more satisfactory method, however, is to use ⅕ cc. intradermal doses of alcoholic precipitated tuberculin in 5 to 50 per cent solutions administered subcaudally, and 2 cc. doses of 10 per cent Koch's Old Tuberculin administered subcutaneously, and take temperatures as in the usual subcutaneous test. With this kind and strength of tuberculin the local reactions are pronounced and the thermal reactions are as characteristic as those that occur from subcutaneous injections alone.

The procedure in injecting cattle is not difficult, provided needles of the proper length are used. To obtain the best results the tuberculin must be injected into the lower layers of the skin or into the subdermal connective tissue. The application of strong disinfectants to the site of injection should be avoided. It requires considerable experience to correctly interpret the local swellings. This is especially true when tuberculin containing glycerin is used.

We do not advocate the substitution of the intradermal for the subcutaneous method by a veterinarian until he has become skilled in its use by practice and observation. The practitioner can easily accomplish this in the routine of his work by applying the two tests simultaneously. Such a procedure cannot injure the accepted subcutaneous method in any way, although it may modify the local intradermal swellings to some extent.

Our observation of the fact that cattle having small, latent, or arrested lesions will sometimes react to the intradermal and not to the

subcutaneous test suggests the possibility of differentiating between latent and acute infections by combining the two tests, but we have not been able to put this into practical use.

When 5 per cent solutions of potent precipitated tuberculin are used both the ophthalmic and intradermal methods equal the subcutaneous test in accuracy, but we have found the ophthalmic method unsuitable for use in routine testing under California conditions, except when the cattle can be kept indoors.

The intradermal method has proven very satisfactory in the out-of-door tuberculin testing frequently necessary in this state and, for the non-official testing of large numbers of cattle, is preferable to the subcutaneous method. It requires more experience to apply the test and interpret the intradermal reactions than is required in testing by the subcutaneous or ophthalmic methods.

Some tuberculous cattle react locally to the intradermal test, but fail to react thermally to the subcutaneous test, while others which react thermally fail to react locally. Obviously, then, it is necessary to use both tests in order to detect the maximum number of reacting cattle. By administering the ophthalmic, intradermal and subcutaneous tests simultaneously, a higher percentage of tuberculous cattle will be detected than if dependence is placed on one test alone.

The intradermal test is especially adapted to the testing of swine and has proven of value in the routine work of the California Hog Serum Laboratory.

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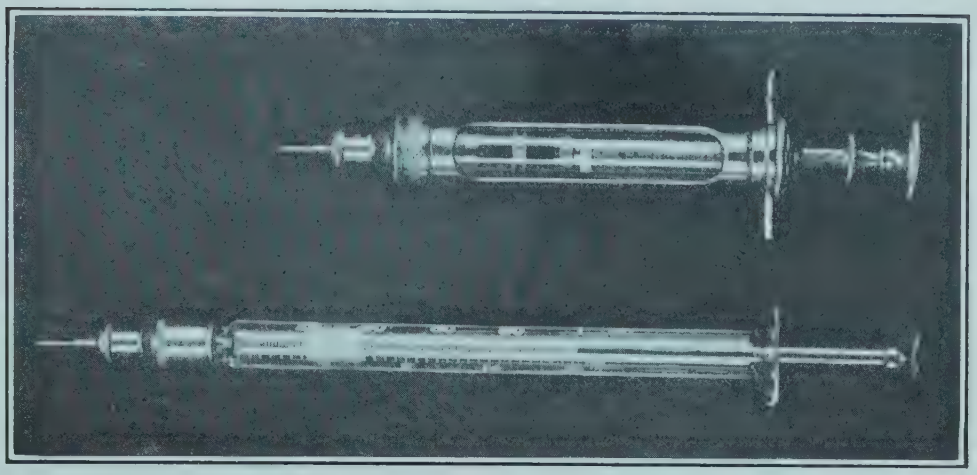
C. M. H.

PLATE 1



FIGURES 1 AND 2

Either of the two syringes shown above is suitable for intradermal injecting. The shorter one is a dental syringe of 30 minims capacity, with a burr on the piston which can be used to regulate the dose. For intradermal work the needle point should be about one-quarter of an inch long.

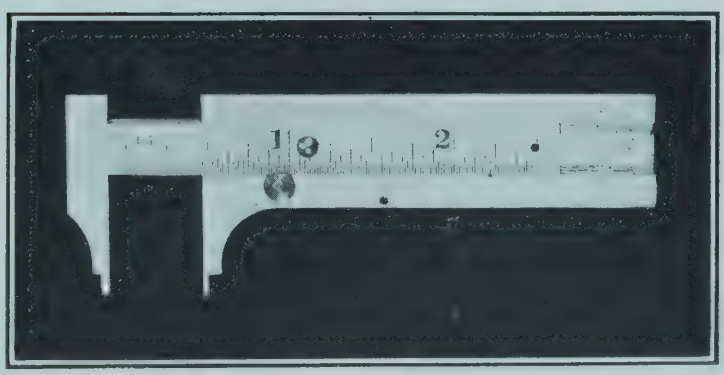



FIGURE 3

Calipers similar to those shown above are useful in determining the exact size reaction of swelling

PLATE 2

In making an intradermal injection, one of the folds of skin beneath the base of the tail is grasped between the thumb and fingers and the needle inserted, slightly horizontally, into the thickness of the skin between the thumb and fingers. If the needle is properly placed the tuberculin can be felt in the deeper layers of the skin as it is injected, and after the removal of the needle the tuberculin can be felt as a lump about the size of a small pea. The best reactions are obtained when the tuberculin is injected into the deeper layers of the skin. Inject deep enough so that the fluid does not swell out the skin like a blister. We consider Figure 1 a more convenient position for operating than Figure 2.

FIGURE 1

FIGURE 2

PLATE 3

The figures in this plate show typical intradermal reactions. A reaction to the intradermal tests is indicated by a swelling or a thickening of the skin at the point of injection. The swelling may be either soft or pendulous, as in Figure 1, or hard and inflamed as in Figure 2.

FIGURE 1

A recognizable reaction may be present at the sixth hour, but generally the reaction swelling is first clear about the twelfth hour and continues to increase in size until the forty-eighth hour.

FIGURE 2

In some instances we have observed that the early local reactions disappear by the forty-eighth hour, while in other cows delayed reactions have been noted that did not appear until the ninetieth hour. In order to be certain of every case, observations should be taken about the thirtieth and seventieth hours after injection.

FIGURE 3

PLATE 4

FIGURE 1

should depend on the shape, appearance, tenseness, sensitiveness and location with respect to the exact point of injection more than upon the actual measurements. Only experience can teach one how to be certain of a positive reaction when the local swelling is small. This is especially true when tuberculin containing glycerin is used.

The use of calipers to determine the exact size of the swellings is shown in the figures on this plate. However, in judging a local swelling to determine if it is a positive reaction to tuberculin, one

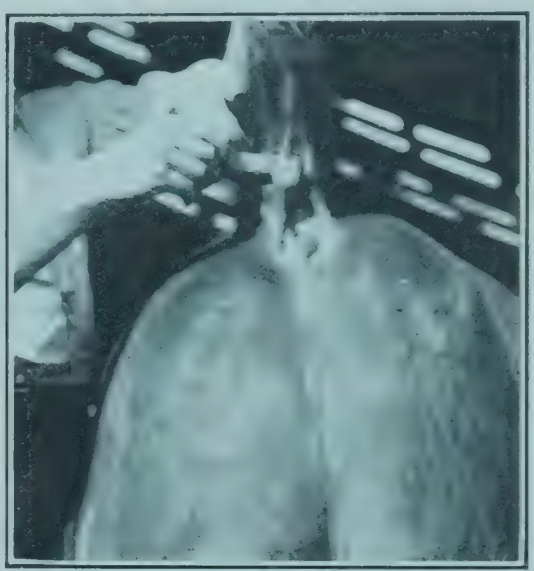


FIGURE 2

FIGURE 3

PLATE 5

FIGURE 1

As shown in Figure 1 the intradermal reaction is sometimes so large that it can be seen without raising the tail.

Figure 2 shows an intradermal reaction that obliterates both subcaudal folds.

FIGURE 2

Figure 3 shows the swellings due to two injections with a six-day interval. The left subcaudal fold was injected July 30th and a local reaction the size of an orange occurred, which persisted several weeks. The right fold was injected August 5th and resulted in a local reaction the size of a walnut. (See Animal 1, Table 6.) Thermal reactions usually accompany intradermal reactions.

FIGURE 3

One advantage of the intradermal reaction is that it often leaves a more or less permanent mark which can be used to identify the reacting animals for several weeks.

PLATE 6

FIGURE 1

Figure 1 is not a cut of a reaction, but shows a swelling caused by the application of a strong solution of lysol. Irritating disinfectants should not be used before applying the intradermal test.

Figure 2 shows an intradermal reaction in a calf six weeks of age. The test is especially adapted to the testing of young calves and wild range cattle.

FIGURE 2

PLATE 7

The ophthalmic or eye test with tuberculin may equal the other forms of tuberculin testing in accuracy, but under the average outdoor conditions of California is not as suitable as the intradermal test.

Figure 1 shows a mild ophthalmic reaction twelve hours after injection.

FIGURE 1

Figure 2 shows a severe ophthmalic reaction twelve hours after injection.

FIGURE 2

PLATE 8

FIGURE 1

FIGURE 2

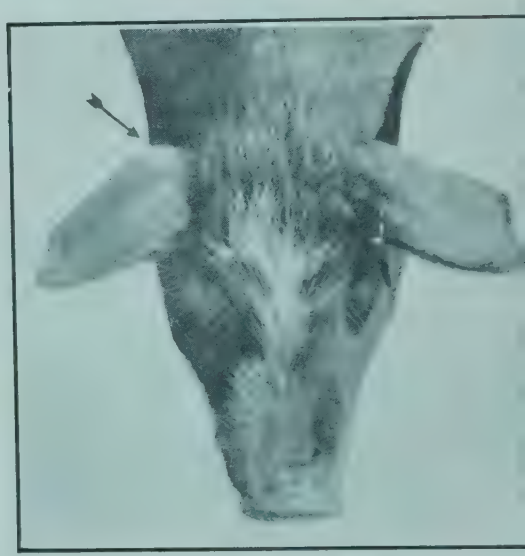


FIGURE 3

The intradermal test is especially adapted to the testing of swine. Injections may be made into the back of the ear near its base as in Figure 1, or into the edge of the ear as in Figure 2. The reaction swellings are similar to those in cattle (see Figure 3).

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# THE DETERIORATION OF LUMBER

*(A Preliminary Study)*

BY

MERRITT B. PRATT

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# THE DETERIORATION OF LUMBER

*(A Preliminary Study)*

By MERRITT B. PRATT

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Lumbermen realize that lumber depreciates considerably from the time it leaves the saw until it is placed on board cars, but have little idea of the amount of injury and the possibilities of reducing the loss.

The present deterioration study followed the lumber from the time it left the sawmill until it was shipped. It determined as definitely as possible the loss in grade due to air-seasoning, kiln-drying, and finishing and the causes leading to the loss. The study was made in the yards of a representative lumber company in the northern part of the Sierra Nevada Mountains of California, and the results obtained are due, in large measure, to the co-operation of that company. The study was undertaken at the suggestion of, and in co-operation with, the United States Forest Service, through Mr. C. Stowell Smith, Assistant District Forester at San Francisco.

The data obtained concerns three species: sugar pine (*Pinus lambertiana* Dougl.); western yellow pine (*Pinus ponderosa* Laws.), which goes by the market name of California white pine; and Douglas fir (*Pseudotsuga taxifolia* Brit.), often called spruce in the market; these being the most valuable timber trees in the Sierras.

## FACTORS AFFECTING DETERIORATION

### AIR-DRYING

Among the important factors which affect the amount of depreciation in air-drying are the location of the yard, the method of piling the lumber, the climate and season of the year, and the dimension of the stock.

*Yard.*—The yard on the operation studied was poorly located for drying purposes. Its lower part was located on a black loamy soil which did not dry out readily and supported a heavy growth of grass and weeds, which retarded circulation of air in the piles. Good circulation of air was also prevented through the crowded condition and general location of the yard, it being only about ten acres in

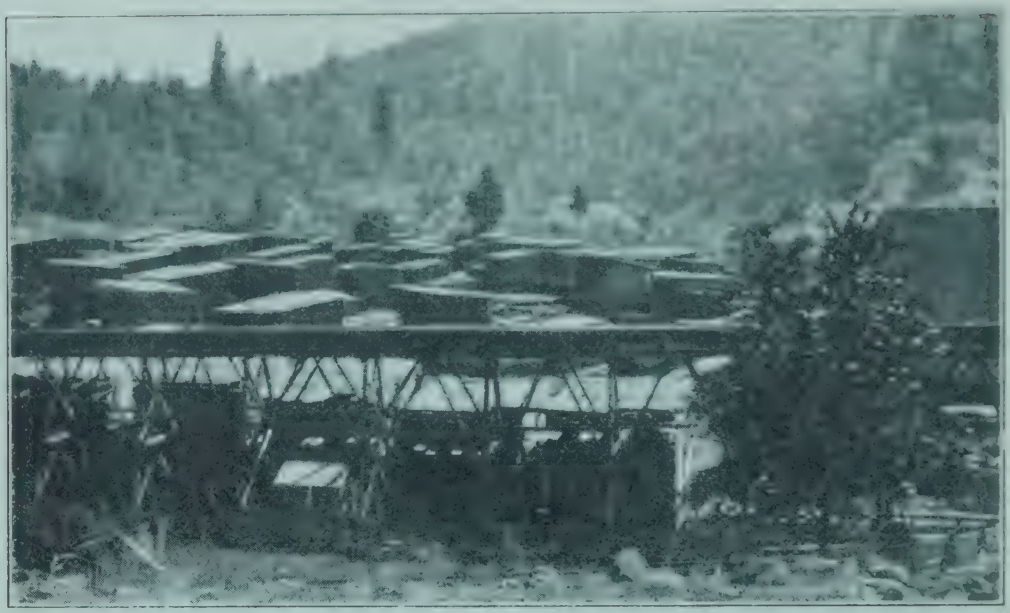

Fig. 1.—Yard in which the air-dried stock was tallied from the piles. Good circulation of air was hindered by surrounding mountains

Fig. 2.—Terminus of flume carrying lumber from the sawmill four and a half miles distant

extent and closely hemmed in by surrounding mountains. The poor conditioning of the pine lumber in the piles in the lower part of the yard can be attributed mainly to poor air circulation. (See fig. 1.) The piles in the upper part, located on well-drained gravelly soil and

with free air circulation, dried out more quickly and with less deterioration in the grade of the lumber.

*Piling.*—Satisfactory conditioning of lumber depends in great measure on the way it is piled. The following principles are essential for good air-drying of sugar pine: (1) Foundation of pile should be solid and have good clearance above ground. (2) Piles should be open to provide for free circulation of air. (3) Stickers, or cross pieces, should be dry and regularly placed to hold the boards straight while they are seasoning. (4) Piles should slope and be well covered so that the water will run off quickly. (5) Piles should not be placed too closely together, since circulation of air will be hindered thereby. (See figs. 3 and 4.)

Fig. 3.—Piles of sugar pine lumber. Poor circulation conditions result from piles being too close together, also by reason of vegetation around the piles. View shows heavy growth of weeds, which tends to impede circulation of air in and around the piles.

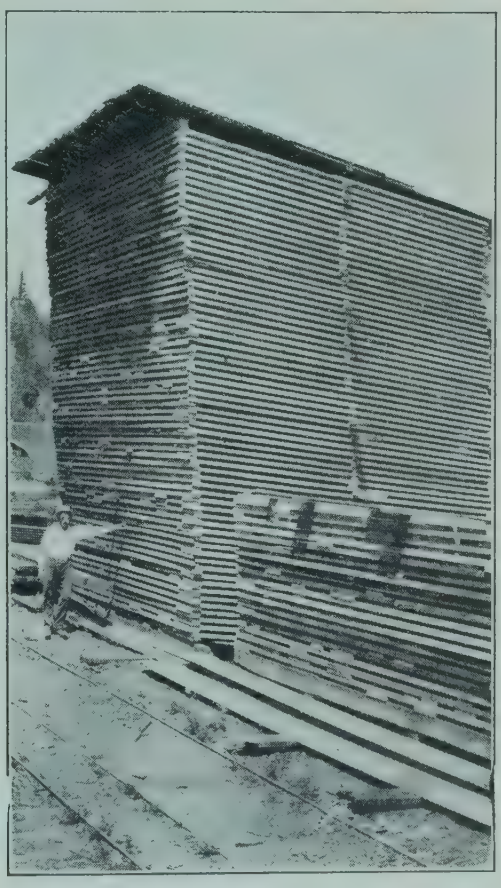

Fig. 4.—Better conditions for drying exist when piles are not shut in by other piles.

These principles were generally followed in the yard studied, except that the foundations in some instances were too low and did not provide for enough slope to the piles for the water to run off freely. This, coupled with the close piling in some places, caused much deterioration in grade on account of stain.

The typical pile was 20 feet high by 16 feet wide. The lumber averaged 16 feet long, 1½ inches thick, and 12 inches wide. The courses were separated by three $2 \times 4 \times 6$ inch Douglas fir stickers surfaced two sides. There were three chimneys 6 inches or more wide through the pile and an average spacing between the boards of 4 inches. The cover consisted of $1 \times 12$ Douglas fir boards projecting about 2½ feet at each end. The foundation was 18 inches from the ground in front and 12 inches in the back to give slope to the pile.

*Climate and Season of the Year.*—In the northern Sierras there is very little humidity in the air from June to October and a good breeze generally prevails during that period. In the spring and fall, on the other hand, there is more or less rainy weather and the circulation conditions are generally poor. Lumber is not sawed in this region in the winter. Lumber can often be well dried in from one to two months in the summer. During the spring and fall it not only requires a longer period to dry the lumber but there is greater depreciation during seasoning.

*Dimension of Stock.*—The thicker and wider the lumber the more liable it is to depreciation. The deterioration of 2-inch lumber was greater than for thinner stock, especially when there was heart on one side and sap on the other. Stock of this size should be sawed all sap or all heart if possible. It should also be cut early enough in the season to allow the stock to become dry before winter.

### DEFECTS CAUSING DETERIORATION IN AIR-DRYING

To determine the loss in grade during air-drying, each board was tallied as it was taken down from the pile for shipment, the grader calling off the original grade as made at the mill when sawed, the present grade after air-drying, the contents in board feet, and the cause of deterioration in grade, if any. The following causes of deterioration were noted: blue stain, brown stain, check and warp, pitch, mechanical defects due to handling, and combinations of these that might change the original grade or footage.

*Blue Stain.*—Blue stain, which is very commonly found in pine lumber, is caused, as a rule, by a number of fungi, the activity of which produces discoloration in the sapwood, where there is an abundant food supply. The color is due in this case to the dark colored mycelium of the fungus, which is found as fine threads in the food-

containing wood rays and the parenchyma cells surrounding the resin cells. It is very likely, however, that some of the blue sap stain is not produced by fungi, but by chemical reactions, the discoloration often taking place very rapidly.

Blue stain is the most serious cause of depreciation in lumber with which lumbermen in northern California have to contend. It develops to a large extent in piles put up in the fall and which do not have time to dry out before the winter rains set in. It also develops where the drying conditions are poor, especially where free circulation of air is retarded by too close piling or by a growth of weeds beneath the pile. It is also brought about by unfavorable atmospheric conditions, such as a cloudy, humid period extending over several days with little or no breeze. Under such conditions lumber cut in the spring or fall blues very rapidly.

Log stain, which is a darker blue and more deeply embedded than the blue stain which develops in piled lumber, may be due to a chemical reaction. It develops very rapidly in logs cut and left in the woods, appearing first on the ends and gradually extending through the sapwood as the bark becomes loosened.

Lumbermen realize the advantages of open piling of pine in combatting blue stain and the necessity of free circulation of air. In many places the weeds are killed by sprinkling quicklime on the ground where the piles are to be placed. Since humid conditions and poor circulation promote blue stain, it is of advantage to have piles on soil with low moisture content and in positions where the air can circulate freely. When piles are shut in by surrounding piles the amount of stain is invariably greater than when the piles are free.

Blue stain does not injure the strength of the wood, since the walls of the wood cells are not destroyed by the fungus. It is the stained appearance of the lumber which seriously decreases its money value.

It is a problem to dispose of stained lumber. A grade of stained clear is made for finishing stock and second-class door cuttings are secured from No. 2 shop, which admits of slightly stained sap not extending over more than one-half of the face of the piece on one side. This must be the only defect, however, or the piece will be graded as box lumber. Some companies have a limited market for stained box shooks for cannery stock. Shippers of high class fruit, however, do not want a stained box, since it detracts from the appearance of the package. A common method of getting rid of stained lower grade lumber is to work it up into sheathing and car strips.

*Brown Stain.*—Brown stain, which is frequently not discernible in lumber until it has been finished, is a very serious defect. Its

presence is not due to fungi, but to a chemical reaction which takes place in green sap lumber upon exposure to the air. When the freshly cut surfaces are exposed to the air, under favorable conditions of temperature and moisture, a chemical reaction results which produces a colored substance on the wood. "Favorable conditions for sap-staining are found during warm weather and optimum conditions during extremely hot, humid summer weather, when lumber becomes discolored within a few hours. The examination of microscopic sections of this sap-stained lumber reveals the fact that the colored substance, produced by the chemical reaction, is most conspicuously developed in the wood rays and wood parenchyma cells, living tissues which are largely concerned in the storage and conduction of food in the wood."[1]

Professor John S. Burd, Agricultural Chemist, University of California, to whom samples of brown-stained sugar pine lumber were submitted, comments as follows:

"I submitted the samples to Professor R. E. Smith of the Division of Plant Pathology, who reports that he is unable to discover any organism in connection with the brown stain produced. This confirms my previous opinion, namely, that brown stain is probably due to oxidation of certain constituents of the wood, the exact character of which is unknown. Mr. Hibbard of this laboratory has treated samples of wood affected by the brown stain with a considerable number of oxidizing and reducing agents and has found it impossible to destroy the color so produced. I am therefore disposed to believe that after the stain has once occurred it will not be practicable to destroy same except by a process which would result in the destruction of the tissues of the wood. This means that in any attempt to mitigate the effects of brown stain it will be necessary to proceed along the lines of prevention rather than cure. In order to follow up such a method it would be necessary to make comparative experiments on timber under field conditions. Such experiments would require that the wood, seasoned by any method, should be checked by comparisons with tests of the same timber seasoned by the usual processes."

Both blue and brown stains are closely related to the food substances contained in the wood. Both of these agencies are dependent upon certain quantities of oxygen from the air, heat, and moisture. The conditions causing the worst sap staining, both blue and brown, are found in green sap lumber during hot, humid weather; whereas conditions tending to prevent staining are found in cool, dry weather and in logs immersed in water.

[1] Bailey, Botanical Gazette, Vol. 50, pp. 142–147. August, 1910.

Brown stain is not found in yellow pine. The presence of the sugary sap in sugar pine probably has something to do with the oxidizing process, resulting in brown stain, which is so common in lumber of that species. Brown stain is especially bad in lumber cut in early spring, when the tree is sappy. It is generally found as a distinct band between the heart and sap wood. Very frequently boards which have been subjected to especially unfavorable drying conditions have both blue and brown stains.

Sugar pine when put in the kiln is very subject to kiln-burn, which cannot be detected in surfaced lumber from the brown stain found in air-dried lumber. In fact, it is probable that it is brown stain caused through defective circulation conditions in the kiln the same as in the pile. (See fig. 5.)

*Check and Warp.*—No checking can occur until the surface of the wood has lost all its free water, that is, water in liquid form filling the pores. When the circulation of air is defective the transmission of water from the interior of the board to the surface does not go on uniformly, uneven drying takes place and case-hardening, followed by checking, results.

End checks are common on account of shrinkage caused by the ends of boards drying out more rapidly than the face. If a freshly cut board is exposed to the sun, the top surface dries out more rapidly than the lower surface, and on account of the uneven drying warping takes place. Uneven seasoning, therefore, results in checking and warping. Much check and warp can be avoided by putting sun covers on the piles during intervals of piling, especially on high grade stock, which does not accumulate very rapidly.

The harder the grain the greater is the liability to check and warp. This was evidenced in several cribs of kiln-dried cross-grained Douglas fir stock, a large proportion of which was checked and warped. Sugar pine does not suffer in grade from these causes nearly so much as yellow pine on account of its softer texture. Yellow pine and Douglas fir check and warp very badly when piled in the yard, consequently the upper grades are kiln-dried by the majority of lumber companies in this region.

*Pitch.*—Oftentimes pitch which is not discernible in the board on the grading tables at the mill appears in seasoning, both in the air-dried pile and in the kiln. It is a very common cause of misgrade at the sawmill. Pitch may occur in small pockets or in streaks, often resulting in the lowering of the grade. An Australian grade is made which admits of considerable pitch, but it is a serious defect in finishing stock used in this country.

Fig. 5.—Brown stain in sugar pine lumber

Fig. 6.—Kiln-burn in sugar pine lumber

Boards taken from the butt ends of trees which have been fire scarred are very pitchy as a rule. Pitch develops wherever the tree has been injured in any way. Pitch seams are found along lines of cleavage caused by wood shake or frost crack. On kiln-dried boards pitch globules are often found, the pitch having been forced out of the boards by the heat and coagulated on the outside.

*Mechanical Defects Due to Handling.*—On the operation studied injury from handling came about in three ways:

Handling of logs in woods in mill.—Sugar pine boards cut from the outside of a thin-barked log are often lowered in grade through too deep dogging in the woods. The turning of the logs in the mill with the steam niggers sometimes mars or breaks the board so that the grade is reduced.

Handling of lumber in flume.—The lumber was transported in a 30-inch V-shaped flume four and a half miles in length. (See fig. 2.) The upper grades are often broken or split by the impact of heavy timbers. Jams sometimes result, the boards being thrown out on the rocks below. Heavy sugar pine boards, known as "sinkers," become waterlogged and sink, and the handling they receive from the iron hooks of the men on the flume often materially reduces the grade. The wider the boards the greater is the danger of injury in the flume. In fact, the damage is so great that wide boards are not cut when the water is low.

Handling in yards.—A very common source of injury comes about in the dumping of the lumber from the flume to the skid through breakage or splitting of the ends of the boards. The lumber is handled several times after it leaves the skids and before it is placed on board cars. Breakage begun in the flume is apt to become intensified every time the lumber is handled. The piling jacks used in getting boards to the tops of piles dig holes into boards unless carefully handled. The loss from handling in the yard, however, is a small item compared with the loss in fluming. (See fig. 7.)

## KILN-DRYING

The artificial seasoning of the upper grades of lumber in dry-kilns is being resorted to more and more by lumbermen, now that methods have been perfected whereby nearly all kinds of lumber can be seasoned with a small percentage of loss.

There are three conditions which must be carefully looked after if lumber is to be kiln-dried successfully. These are heat, air circulation, and humidity. If each of these factors can be properly controlled the lumber can be successfully dried. To avoid split, warp, and check it is essential that a definite relation be maintained between

the evaporation from the surface and the transmission of moisture within the board. This condition can be obtained by observing the following principles:

(1) The temperature of the lumber must be maintained uniformly throughout the entire pile.

(2) A large and continuous circulation of air must be maintained.

(3) Control of the drying process at any given temperature must be secured by controlling the relative humidity, not by decreasing the air circulation. This may be accomplished either by suitable ventilation or by having steam jets in the kiln.[2]

The kiln used in the operation studied is an old type, operated by the steam heat blower system, live steam being carried to the steam coils from the boiler. The heated air is forced through ventilators in the front of the kiln, up through the lumber to the top and down the side walls to the air drum, which carries it again to the steam coils. A continuous circulation of air is kept up by a fan situated in front of the steam coils. Lumber is gradually moved to the discharging end of the kiln, the moisture being taken up by the heated air until the lumber reaches the degree of dryness desired.

Temperature, humidity, and air circulation were exceptionally well regulated in the kiln studied, but the loss, although less than in air-drying, is a considerable item. The loss in grade was chiefly due to check, split, and warp in yellow pine and Douglas fir and kiln-burn and check in sugar pine.

The checking and splitting took place generally in hard, cross-grained pieces. It also was found in cribs of lumber where the proper relations had not been maintained between the evaporation from the surface and the transmission of moisture within the board.

Kiln-burn in sugar pine usually causes such a large amount of deterioration that many operators do not attempt to kiln-dry it, except when it must otherwise be left to dry in the yards over winter. In this case the upper grades are put in the kiln with the idea that the lumber could not possibly be spoiled to a greater degree than if left green in the yard.

The system of kiln-drying sugar pine has usually been that of keeping a low, steady temperature during the entire drying period. The experiment was made in the kiln studied of subjecting sugar pine to the same heat as yellow pine, starting with 130° and gradually raising it to 180° before the lumber was removed from the kiln. The kiln-burn was much less with this method than under the low heat system. Much investigation, however, is needed before this matter can be definitely settled. (See fig. 6.)

[2] Tiemann, Principles of Drying Lumber at Atmospheric Pressure, Bulletin 104, Forest Service, U. S. Dept. of Agr., p. 6.

Fig. 7.—Lumber on skids as dumped from the flume

Fig. 8.—Crib of kiln-dried yellow pine ready to be regraded. Lateral chimneys shown

### SURFACING

The grade of lumber as taken down from the pile or from the kiln does not always hold after it has been surfaced. Planing may improve the grade by removing the defects which kept the grade down in the rough, but it generally brings to light defects such as brown stain or check that were not before discernible, thereby causing the grade to fall.

In order to secure this factor of reduction, a quantity of lumber that had already been tallied from the kiln or from the yard was tallied through the planer, the complete history being obtained from the time the lumber left the mill until it was put on board cars.

### DATA SECURED IN THE PRESENT STUDY

The following are the average prices received for the different grades of lumber in this vicinity at the time the study was made and upon which the monetary loss as given is based:

PINE

| Grade | Selling price per 1000 bd. ft. |
|---|---|
| No. 1 and No. 2 clear sugar pine | $54.00 |
| No. 1 and No. 2 clear yellow pine | 40.00 |
| No. 3 clear sugar pine | 42.00 |
| No. 3 clear yellow pine | 35.00 |
| No. 1 shop sugar pine | 29.00 |
| No. 1 shop yellow pine | 26.00 |
| No. 2 shop sugar pine | 20.00 |
| No. 2 shop yellow pine | 17.50 |
| Australian | 34.50 |
| Stain clear | 30.00 |
| Box | 15.00 |

DOUGLAS FIR

| Grade | Selling price per 1000 bd. ft. |
|---|---|
| Clear | $27.50 |
| Select | 22.50 |
| No. 1 and No. 2 dimension | 16.50 |
| No. 3 dimension | 12.00 |

### AIR-DRIED LUMBER

Sugar pine lumber was tallied from piles which had been put up in the fall, spring, and summer, since it is evident that drying conditions vary considerably with the season irrespective of the way the pile is put up. The percentage of loss varied greatly, the greatest depreciation in grade being found in the fall-piled lumber and the

least in the summer-piled stock. Blue stain was especially bad in fall piles. The following tables show the amount of depreciation under various conditions.

FALL-PILED SUGAR PINE

Total amount tallied, 41,812 bd. ft.

| Original grade | Thickness of lumber, inches | Proportion of lumber deteriorating in grade, per cent | Chief cause of deterioration and proportion of all lumber in pile affected by it | Loss per 1000 bd. ft. from all causes, dollars |
|---|---|---|---|---|
| 1 and 2 clear* | 6/4 | 75.5 | Blue stain, 52% | 17.90 |
| 3 clear | 6/4 | 71.2 | Blue stain and check, 54% | 11.27 |
| 1 shop | 5/4 | 70.6 | Blue stain and check, 36% | 8.87 |
| 1 shop | 4/4 | 68.0 | Blue and brown stains, 62% | 9.96 |

* Field data on one pile 1 and 2 clear taken by Swift Berry, Forest Examiner, U. S. Forest Service.

SPRING-PILED SUGAR PINE

Total amount tallied, 51,147 bd. ft.

| Original grade | Thickness of lumber, inches | Proportion of lumber deteriorating in grade, per cent | Chief cause of deterioration and proportion of all lumber in pile affected by it | Loss per 1000 bd. ft. from all causes, dollars |
|---|---|---|---|---|
| 1 shop | 6/4 | 41 | Blue stain and check, 21% | 4.23 |
| 1 shop | 8/4 | 56 | Blue stain and check, 43% | 6.35 |
| 2 shop | 6/4 | 21 | Blue stain and check, 15% | 1.11 |
| 2 shop | 8/4 | 36 | Blue stain and check, 24% | 1.82 |

SUMMER-PILED SUGAR PINE

Total amount tallied, 225,156 bd. ft.*

| Original grade | Thickness of lumber, inches | Proportion of lumber deteriorating in grade, per cent | Chief cause of deterioration and proportion of all lumber in pile affected by it | Loss per 1000 bd. ft. from all causes, dollars |
|---|---|---|---|---|
| 1 and 2 clear | 4/4 | 11.6 | Blue stain and handling, 8.7% | 3.03 |
| 3 clear | | | | 2.31 |
| Australian | | | | 1.94 |
| 1 shop | | | | 1.32 |
| 1 and 2 clear | 5/4 | 11 | Blue stain and handling, 6% | 3.18 |
| 3 clear | | | | 1.74 |
| Australian | | | | 1.63 |
| 1 shop | | | | .57 |
| 1 and 2 clear | 6/4 | 13.2 | Check, 2.8%<br>Handling, 4.2%<br>Blue stain, 2.6%<br>Brown stain, 2% | 2.95 |
| 3 clear | | | | 3.42 |
| 1 shop | | | | 1.02 |
| 1 and 2 clear | 8/4 | 29.7 | Check, 11.7%<br>Blue stain, 8.4%<br>Handling, 4% | 7.47 |
| 3 clear | | | | 6.66 |
| Australian | | | | 2.42 |
| 1 shop | | | | 1.03 |
| 2 shop | | | | .62 |

* This lumber was tallied by S. B. Show, Forest Examiner, and E. B. Long, Forest Ranger, both of the U. S. Forest Service.

The lumber which was found to have held its grade in the No. 2 shop piles in the spring-piled sugar pine, amounting to 19,838 board feet, was then surfaced on two sides for shipment and again graded after surfacing. Some of the defects surfaced out, while others, particularly brown stain, appeared. There was a gain of 47 cents per thousand board feet in the lot from one pile of No. 2 shop and a loss of 31 cents per thousand board feet in the other pile through surfacing.

Mr. Show also tallied 5310 board feet of No. 3 clear sugar pine, which was surfaced two sides directly after it had been taken down from a pile of summer-dried stock. It was found that there was a loss of $1.44 per thousand board feet due to blue and brown stains which did not show up in the rough.

### KILN-DRIED LUMBER

*Sugar Pine.*—It has not been the practice of the lumber company in whose yards this study was made to kiln-dry sugar pine because of the loss to which it was thought it would be subject from kiln-burn. An experimental run of 14,000 board feet of No. 1 and No. 2 shop was made, however, to compare the loss in grade with summer air-dried stock. The following comparatively small loss was the surprising result:

Total amount tallied, 14,000 bd. ft.

| Original grade | Thickness of lumber, inches | Proportion of lumber showing deterioration per cent | Chief cause of deterioration | Loss per 1000 bd. ft. from all causes, dollars |
|---|---|---|---|---|
| 1 shop | 6/4 | 8 | Check and kiln-burn | 1.82 |
| 1 shop | 8/4 | 12 | Check and kiln-burn | 1.90 |
| 2 shop | 6/4 | 2 | Check and kiln-burn | .11 |
| 2 shop | 8/4 | 5 | Check and kiln-burn | .27 |

The lumber which held its grade, amounting to 9028 board feet, was then surfaced and again graded. Additional check and kiln-burn appeared, causing a further depreciation of 26 cents per thousand board feet for No. 1 shop and 5 cents per thousand board feet for No. 2 shop.

*Western Yellow Pine.*—The lumber was piled wide apart so that every board would be exposed to the warm air and evaporation of moisture would take place readily. There was an average of twenty-eight courses of 1½-inch lumber to the car, with three lateral 4-inch chimneys made by placing 2 × 4 inch stickers at the bottom of the

twelfth, eighteenth, and twenty-fourth courses from the top. The average length of drying was ten days. (See fig. 8.)

Total amount tallied, 80,000 bd. ft.

| Original grade | Thickness of lumber, inches | Proportion of lumber showing deterioration per cent | Chief cause of deterioration | Loss per 1000 bd. ft. from all causes, dollars |
|---|---|---|---|---|
| 1 and 2 clear | 4/4 | 5 | Check | .70 |
| 1 and 2 clear | 5/4 | 14 | Check | 1.25 |
| 1 and 2 clear | 6/4 | 6 | Check | .71 |
| 1 and 2 clear | 8/4 | 23 | Check | 3.41 |
| 3 clear | 6/4 | 6 | Check | .64 |
| 3 clear | 8/4 | 23 | Check | 3.46 |
| Australian | 8/4 | 23 | Check | 2.42 |
| 1 shop | 4/4 | 5 | Check | .85 |
| 1 shop | 6/4 | 6 | Check | .64 |
| 1 shop | 8/4 | 23 | Check | 2.31 |
| 2 shop | 8/4 | 23 | Check | .65 |

A further depreciation was found to take place in yellow pine lumber which was surfaced after being taken directly from the kiln, as shown in the following table:

Total amount tallied, 12,709 bd. ft.

| Original grade | Thickness of lumber, inches | Proportion of lumber showing deterioration, per cent | Chief cause of deterioration | Loss per 1000 bd. ft. from all causes, dollars |
|---|---|---|---|---|
| 3 clear | 8/4 | 6 | Check | .72 |
| 1 shop | 8/4 | 4 | Check | .70 |
| 2 shop | 6/4 | 2 | Check | .11 |

*Douglas Fir.*—The lumber was piled very closely to keep it from drying out too quickly. There was an average of thirty-four courses of inch lumber to the car, with two lateral 4-inch chimneys made by placing 2 × 4 inch stickers at the bottom of the eighteenth and twenty-eighth courses from the top. Douglas fir lumber in this vicinity is of very hard texture and warps and checks badly if not carefully treated in the kiln. Even then cross-grained stock warps and splits because of its extreme hardness. The few pieces of 2-inch lumber put in with the inch stock showed a large proportion of check. The average length of drying was five days.

Total amount tallied, 53,000 bd. ft.

| Original grade | Thickness of lumber, inches | Proportion of lumber showing deterioration, per cent | Chief cause of deterioration | Loss per 1000 bd. ft. from all causes, dollars |
|---|---|---|---|---|
| Clear | 4/4 | 9 | Check and warp | .73 |
| Clear | 8/4 | 16 | Check and warp | 2.91 |
| Clear | 4/4 | 9 | Check and warp | .32 |

SURFACED LUMBER

In addition to the surfaced lumber amounting to 19,838 board feet of spring-piled air-dried sugar pine, 5310 board feet of summer-piled air-dried sugar pine, 9028 board feet of kiln-dried sugar pine, and 12,709 board feet of kiln-dried yellow pine, which was again graded directly after it had been taken from the pile and kiln and the results of which have already been stated, the following data were taken regarding change in grade due to surfacing of lumber which had been stored in sheds.

*Sugar Pine, Surfaced Two Sides.*—The lumber in the following table had been graded down from the piles the year before and stored in the sheds until needed. The brown stain shown in surfacing either was not detected by the grader in the rough or developed in storage, since this proportion of deterioration was not found in lumber taken directly from the piles to the planer.

Total amount tallied, 38,000 bd. ft.

| Original grade | Thickness of lumber, inches | Proportion of lumber deteriorating in grade, per cent | Chief cause of deterioration and proportion of all surface lumber affected by it | Loss per 1000 bd. ft. from all causes, dollars |
|---|---|---|---|---|
| 1 shop | 5/4 | 54 | Brown stain, 32% | 7.43 |
| 1 shop | 8/4 | 45 | Brown stain, 24% | 5.45 |
| 2 shop | 6/4 | 31 | Brown stain, 21% | 1.54 |

Considerable trouble is experienced in shipping sugar pine because of brown stain. Cases have been known where there was apparently no brown stain in the lumber at the time it was shipped, but which was found by the consignee when the car reached him. One company lost a hundred dollars on a car of high grade stock through brown stain, which was not apparent at the time of shipping. The probabilities are that the lumber was not thoroughly dry when it was shipped. The many complaints along this line are leading lumbermen dealing in sugar pine to use the utmost care in its seasoning.

*Western Yellow Pine, Surfaced Two Sides.*—As a basis of comparison with the loss sustained by sugar pine taken from the sheds, kiln-dried yellow pine which had also been stored was followed through the planer and tallied when loaded on board cars. The absence of brown stain made the loss per thousand board feet much lower than for sugar pine, but it was greater than for lumber surfaced after being taken directly from the kiln. A greater amount of check was apparent, which may have been due to storage conditions.

Total amount tallied, 29,103 bd. ft.

| Original grade | Thickness of lumber, inches | Proportion of lumber deteriorating per cent | Chief cause of deterioration | Loss per 1000 bd. ft. from all causes, dollars |
|---|---|---|---|---|
| 1 and 2 clear | 4/4 | 5 | Check | 1.63 |
| 1 and 2 clear | 6/4 | 10 | Check | 3.22 |
| 1 and 2 clear | 8/4 | 3 | Check | 1.97 |

## SUMMARY

The data gathered in this preliminary study are not sufficient in amount, range of conditions, or length of time to warrant a statement of final conclusions either as regards the amount of the loss or the best means of reducing that loss. The object of this report is to call attention to the fact that this is a problem worthy of careful study and to make available at once such data as are now at hand. The United States Forest Service is conducting much more extensive investigations along the same line over a wide range of conditions.

The present figures show that the loss due to depreciation in the grade of the lumber from the time it leaves the saw until it is shipped is far greater than was generally imagined. This is especially true for sugar pine, which is considered the most valuable species in the Sierras and for which the highest stumpage rate is asked by the United States Forest Service. Sugar pine lumber appears to be extremely susceptible to depreciation, particularly to blue stain and brown stain. On account of the rate at which it deteriorates in this locality, the company in whose yards data concerning it were taken contends that it is making more profit on its western yellow pine (known to the trade as California white pine), the upper grades of which can be kiln-dried without an undue amount of loss. If sugar pine could be kiln-dried successfully, and it is believed that this will be done in a short time, the present large loss through air-seasoning would be greatly decreased.

The following conclusions regarding the deterioration of the upper grades of sugar pine, western yellow pine, and Douglas fir from the time the lumber leaves the sawmill until it is ready for shipment are indicated by the limited amount of data thus far available.

### SUGAR PINE

1. The upper grades of sugar pine deteriorated much more in seasoning than did western yellow pine or Douglas fir. Of the sugar pine lumber of the upper grades, the percentage which deteriorated in grade during air-seasoning was approximately 71 per cent, 38 per cent, and 16 per cent for the fall, spring, and summer drying, respectively. When surfaced there was a further deterioration due to brown stain; this was greater in the lumber taken from the storage sheds than in that taken direct from the piles.

2. The average loss for all lumber tallied in unfinished upper grades of sugar pine through fall seasoning was approximately $12 per thousand board feet as compared with an average loss of $2.58 per thousand board feet through summer seasoning.[3] The average loss through spring seasoning cannot be given in comparable terms, inasmuch as no spring seasoned lumber above No. 1 shop was tallied. From the loss in No. 1 shop, however, it is estimated that the average loss in spring seasoning for all the upper grades was about $5 per thousand board feet.

3. One experiment in kiln-drying sugar pine at the same temperature as western yellow pine and Douglas fir indicated that the deterioration in the upper grades of sugar pine lumber would be much less if kiln-dried than when air-dried in the spring or fall. Ninety-three per cent of the small amount of No. 1 and No. 2 shop lumber which was run through the kiln retained its original grade, and there was an average loss of only $1 per thousand board feet for all the lumber in this lot. The depreciation in surfacing caused an additional loss of 26 cents per thousand board feet for No. 1 shop and 5 cents per thousand for No. 2 shop. This total loss is about the same as that of air-dried summer-piled lumber of these grades. Until the matter of kiln-drying sugar pine has been worked out more satisfactorily, however, it seems preferable to air-dry the summer-cut stock.

4. Blue stain and brown stain, the greatest sources of depreciation in sugar pine lumber, are largely the result of poor drying conditions.

[3] The average is computed for all lumber, including that which did not deteriorate at all. The relative amounts and thickness of each grade were not considered in making the averages, which are only approximate. For losses by grades see tables given previously.

i.e., imperfect circulation of air, poorly drained soil, failure of the pile to shed rainwater, or damp, rainy weather. It is necessary that the air should circulate above, below, and around each board. Less stain developed in piles in the open than in those shut in and less in piles which were located on well drained areas than when on soils retentive of moisture. Stain developed to a great extent in piles put up in the fall when humid atmospheric conditions prevailed. Some piles put up in the spring showed stain more than others, depending on their location. In summer, when dry, breezy conditions prevailed, the lumber did not depreciate any more from stain than from other agencies, such as check and handling.

5. Although the heavy loss of grade in air-seasoned sugar pine is due in part to poor yards and handling, yet under any conditions of seasoning a large loss is liable to occur, due to the sensitiveness of the wood to blue stain and brown stain. This characteristic of the lumber should be considered in fixing stumpage rates; the value should be fixed in accordance with the ultimate grade and value of the species rather than its grade and value at the saw. The present data lead to the conclusion that the proper relationship does not now exist in the vicinity studied between the stumpage price paid for sugar pine and for western yellow pine.

### WESTERN YELLOW PINE (CALIFORNIA WHITE PINE)

Experience has proved that air-dried western yellow pine lumber checks so badly in this vicinity that it pays to kiln-dry all of the upper grades. Approximately 80 per cent of the western yellow pine tallied in this study retained the original grade as made at the mill after the lumber had been kiln-dried and surfaced. The average loss through deterioration during kiln-drying of the upper grades was approximately $1.55 per thousand board feet. When the lumber was surfaced on two sides there was a further loss ranging from 51 cents per thousand board feet in lumber taken directly from the kiln to $2.27 per thousand board feet in that stored in the sheds. More checking occurs in western yellow pine when the kiln is crowded or the lumber piled close together than when there is ample room for circulation. The thicker the lumber the greater is the deterioration due to check.

### DOUGLAS FIR

The upper grades of Douglas fir are very successfully kiln-dried. Experience has shown that in this locality it does not pay to air-dry the upper grades of this species and that kiln-drying is the only practicable method of getting it through with anything like its original grade. Approximately 91 per cent of the upper grades of Douglas fir one inch in thickness retained the original grade when shipped after being kiln-dried. The average loss through deterioration due to kiln-drying was 53 cents per thousand board feet for 1-inch lumber and $2.90 per thousand board feet for 2-inch lumber, which checks very badly.

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# SIZE GRADES FOR RIPE OLIVES

BY

FREDERIC T. BIOLETTI

BUREAU OF ECONOMIC BOTANY, GOVERNMENT ...
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# SIZE-GRADES FOR RIPE OLIVES

By FREDERIC T. BIOLETTI

*Uses and Methods of "Sizing."*—Pickled olives are sorted into several grades based on size. This is necessary for various reasons. When the sizes are mixed, the olives are less attractive in appearance. The large sizes have a greater commercial value. The price paid by the pickler to the grower depends on the size of the fruit. Finally, it is impossible to process olives of various sizes together with the best results.

Various devices are used to separate the various size-grades, but they all depend on the variations in the shortest diameter of the olive. The unit of measurement used is called a "sixteenth," which means a sixteenth of an inch. Olives with a diameter of less than 9 sixteenths are usually rejected for pickling. All above this size are separated into grades differing from each other by one or more sixteenths of an inch.

No accepted standard of grades has been established for olives as for prunes and raisins. An examination of the various brands of canned and bottled olives on the market shows great diversity both in the segregation of the various grades and in the methods of designating them. Uniformity in this matter is very desirable. The buyer wants to know exactly what he is getting; the seller needs to know exactly what the buyer is ordering.

*Variations in Practice.*—In order to determine the variations in practice and whether there was any tendency towards uniform standards, an examination was made of a number of samples of olives collected in the open market. Of these samples eighteen were in bottles and thirty-three in cans. They include the best brands of eleven picklers and handlers of northern, central, and southern California, and therefore represent the present practice fairly.

The examination included the volume of the container, the weight of the olives and of the brine, and the number of olives. Certain samples of typical sizes were carefully measured to determine variations in size. Some of the data obtained is given in the following table:

## TABLE I

### Size-Grades of Commercial Ripe Olives

| Sample No. | Designation on can or bottle | Weight of Olives lbs. | Size of container | Number of Olives | Number of Olives per lb. | Mean diam. 16ths in. |
|---|---|---|---|---|---|---|
| 5 | Jumbo. Sevillano | .85 | *b* 640 cc. | 30 | 35.5 | 16.05 |
| 23 | Jumbo. Net contents 1 qt. | 1.22 | ..... | 53 | 43.6 | ..... |
| 22 | Jumbo. Net weight 2 lbs. | 1.12 | ..... | 54 | 48.3 | ..... |
| 19 | Fancy | 1.47 | *b* 950 | 73 | 49.7 | ..... |
| 20 | Fancy | .26 | *b* 225 | 14 | 53.4 | ..... |
| 1 | Fancy. Mission | .95 | *b* 640 | 56 | 58.9 | 13.63 |
| 12 | X Mission | 1.02 | *b* 665 | 63 | 61.4 | 13.60 |
| 6 | No. 1 Mission | .88 | *b* 640 | 54 | 61.5 | 13.70 |
| 9 | Extra Fancy Mission and Manzanillo | .99 | *b* 700 | 64 | 64.6 | 13.30 |
| 13 | XX Mission | .96 | *b* 665 | 65 | 67.6 | 13.24 |
| 43 | Large size. Contents 20 oz. | 1.66 | 1035 | 112 | 68.0 | ..... |
| 10 | Fancy Mission | 1.00 | *b* 700 | 72 | 73.4 | 12.69 |
| 24 | Fancy. 1 qt. net.; 1 lb. 4 oz. net wgt. | 1.37 | 970 | 100 | 73.0 | ..... |
| 47 | Fancy. Net wgt. 16 oz. | .53 | 485 | 39 | 73.0 | ..... |
| 15 | Mammoth size. Mission | .62 | 460 | 46 | 73.8 | ..... |
| 25 | Fancy. 1 pt. net; 10 oz. net wgt. | .67 | 490 | 49 | 74.0 | ..... |
| 37 | Fancy. Net wgt. 16 oz. | .53 | 485 | 39 | 75.0 | ..... |
| 14 | XXX Mission | 1.07 | *b* 665 | 81 | 75.7 | 12.57 |
| 38 | Fancy. 1 qt. net; 1 lb. 4 oz. net wgt. | 1.30 | 970 | 100 | 76.0 | ..... |
| 18 | Mission | .65 | *b* 475 | 50 | 77.4 | ..... |
| 39 | Fancy. 1 pt. net; 10 oz. net wgt. | .61 | 490 | 49 | 80.0 | ..... |
| 2 | Extra large. Mission | 1.08 | *b* 640 | 91 | 84.0 | 11.89 |
| 36 | Fancy. Net wgt. 2 lbs. | 1.05 | 965 | 91 | 86.0 | ..... |
| 31 | Net contents 1 pt.; wgt. olives min. 9 oz. | .57 | 485 | 50 | 87.0 | ..... |
| 7 | No. 2 Mission | .91 | *b* 640 | 80 | 87.9 | 11.98 |
| 50 | 9 oz. net | .68 | 530 | 60 | 88.0 | ..... |
| 44 | Net wgt. olives min. 1 lb. 3 oz. | 1.21 | 970 | 108 | 89.0 | ..... |
| 46 | Fancy. Net wgt. 2 lbs. | 1.13 | 965 | 90 | 89.0 | ..... |
| 16 | Extra large size. Mission | .58 | 460 | 52 | 89.6 | ..... |
| 48 | Extra large size. 29 oz. net wgt. | 1.14 | 855 | 103 | 91.0 | ..... |
| 30 | Net wgt. olives min. 1 lb. 3 oz. | 1.19 | 970 | 111 | 92.0 | ..... |
| 32 | Extra large size. 29 oz. net wgt. | 1.14 | 855 | 106 | 92.0 | ..... |
| 45 | Net contents 1 pt.; wgt. olives min. 9 oz. | .57 | 485 | 53 | 93.0 | ..... |
| 29 | Large size. Contents 20 oz. | 1.25 | 1035 | 118 | 94.0 | ..... |
| 11 | Large Mission | 1.10 | *b* 700 | 106 | 95.9 | 11.55 |
| 28 | Net wgt. 30–32 oz. | 1.11 | 855 | 100 | 98.0 | ..... |
| 21 | Fancy | .14 | *b* 150 | 14 | 98.6 | ..... |
| 27 | Net contents 15 oz. | .55 | 475 | 55 | 99.0 | ..... |
| 51 | Fancy | 1.07 | 840 | 108 | 101.0 | ..... |
| 35 | 9 oz. net | .60 | 530 | 61 | 102.0 | ..... |
| 26 | Contents, incl. brine, 1 lb. 13 oz. | 1.08 | 860 | 111 | 103.0 | 11.57 |
| 34 | 18 oz. fruit net | 1.21 | ..... | 125 | 103.0 | ..... |
| 3 | Large. Mission | 1.06 | *b* 640 | 109 | 103.0 | ..... |

Note.—Samples marked *b* were in bottles, the others in cans.

TABLE I—(*Continued*)

SIZE-GRADES OF COMMERCIAL RIPE OLIVES

| Sample No. | Designation on can or bottle | Weight of Olives lbs. | Size of container | Number of Olives | Number of Olives per lb. | Mean diam. 16ths in. |
|---|---|---|---|---|---|---|
| 42 | Net wgt. 30–32 oz. | 1.03 | 855 | 107 | 104.0 | ..... |
| 40 | Contents, incl. brine, 1 lb. 13 oz. | 1.11 | 860 | 117 | 105.0 | ..... |
| 41 | Net contents 15 oz. | .61 | 475 | 65 | 105.0 | ..... |
| 17 | Large size. Mission | .60 | 460 | 66 | 110.0 | ..... |
| 49 | 18 oz. fruit net | 1.31 | 995 | 125 | 115.0 | ..... |
| 4 | Medium. Mission | 1.04 | *b* 640 | 133 | 127.1 | 9.95 |
| 33 | 15 oz. net wgt. | .58 | ..... | 80 | 136.0 | ..... |
| 8 | No. 3 Mission | .89 | *b* 640 | 139 | 156.4 | 9.98 |

NOTE.—Samples marked *b* were in bottles, the others in cans.

This table shows great variation in usage. Samples labeled *Jumbo* or *Mammoth* vary from 36 to 74 per pound; *Fancy* from 50 to 108; *Extra Large* from 84 to 106, and *Large* from 68 to 110. It is thus possible to buy olives labeled "Large" which require only 68 to make a pound, while "Mammoth" olives might require 74 and "Extra Large" 106.

It is desirable that the cans should be designated by words, numbers or signs that would give the buyer information on the size and weight of the olives he is buying, and also perhaps of the number in a can.

*Tendency of Current Practice.*—There seems to be a general tendency to distinguish by descriptive words five sizes. These are (1) Jumbo, Mammoth or Extra Fancy; (2) Extra Large or Fancy; (3) Large; (4) Medium; (5) Small. Some label their various sizes 1, 2, 3, etc.; others X, XX, XXX. Table II shows that the first four sizes include olives whose average diameter range from 16 sixteenths to 10 sixteenths of an inch. Those smaller than this are not often pickled for the general market. While this general tendency exists, the individual variations are very great and the words, numbers and signs of the various brands have no common standard or meaning.

*Basis for a Common Standard.*—In order to establish the basis for a common standard, an attempt was made to discover the relation between diameter and number per pound. The data in Table II indicate that this is not a fixed ratio. It varies in fact according to the shape of the olive and its specific gravity. With the same diameter it will require more olives of a rounded variety, like the Manzanillo, to weigh a pound than of an elongated variety, like the Sevillano.

Fresh olives will weigh less than pickled olives of the same size and shape, owing to the salt contained in the latter.

TABLE II

RELATION OF DIAMETER TO WEIGHT AND DESIGNATION

| Sample No. | Designation | Diameter in 16ths of an inch | | | Length | Number | |
|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Mean D | Mean L | per lb. | L/D |
| 5 | Jumbo | 17.12 | 15.04 | 16.05 | 21.41 | 35.5 | 1.334 |
| 6 | No. 1 | 15.04 | 12.80 | 13.70 | 18.32 | 61.5 | 1.338 |
| 1 | Fancy | 14.88 | 12.64 | 13.63 | 18.05 | 58.9 | 1.357 |
| 12 | X | 14.08 | 13.12 | 13.60 | 16.48 | 61.4 | 1,212 |
| 9 | Extra Fancy | 13.76 | 12.48 | 13.30 | 17.17 | 64.6 | 1.291 |
| 13 | XX | 14.40 | 12.48 | 13.25 | 16.59 | 67.6 | 1.252 |
| 10 | Fancy | 14.08 | 11.68 | 12.69 | 17.62 | 73.4 | 1.388 |
| 14 | XXX | 13.44 | 12.00 | 12.57 | 15.74 | 75.7 | 1.250 |
| 7 | No. 2 | 12.80 | 11.36 | 11.98 | 15.90 | 87.9 | 1.327 |
| 2 | Extra Large | 12.48 | 11.36 | 11.89 | 16.56 | 84.0 | 1.393 |
| 3 | Large | 12.00 | 10.24 | 11.57 | 15.87 | 103.0 | 1.372 |
| 11 | Large | 12.32 | 10.24 | 11.55 | 15.55 | 95.9 | 1.346 |
| 8 | No. 3 | 10.72 | 8.64 | 9.98 | 14.00 | 156.4 | 1.402 |
| 4 | Medium | 10.40 | 9.28 | 9.95 | 14.57 | 127.1 | 1.466 |

For olives of the same shape and specific gravity the number per pound will vary inversely as the cube of the diameter. For example, an olive whose diameter is 16 sixteenths will weigh 8 times as much as a similar olive whose diameter is only 8 sixteenths. It will therefore require 8 times as many of the latter as of the former to weigh a pound.

While the olives of a given variety vary somewhat in shape, according to stage of development and other factors, these variations lie normally within certain limits and the average shape of well-developed olives of any variety is fairly constant. This makes it possible to find a factor which will enable us to calculate the number of olives per pound for any diameter of a given variety with a fair degree of accuracy. This factor will be different for each variety of different shape and will depend particularly on the elongation of the olive or the ratio between length and thickness.

From a large number of weighings and measurements, a factor has been determined for each of several of our principal pickling olives and from this factor the number of olives to the pound for the various sizes. The results are shown in Table III.

TABLE III

RELATION OF DIAMETER TO NUMBER PER POUND FOR VARIOUS VARIETIES OF OLIVES (PICKLED)

Number per pound $= K \div D^3$

| Diameter | Manzanillo No. 1 | Ascolano | Agostino | Cucco | Fairoaks | Average | Mission |
|---|---|---|---|---|---|---|---|
| 8 | 313 | 290 | 286 | 264 | 257 | 282 | *244 |
| 9 | 220 | 204 | 199 | 186 | 181 | 198 | *190 |
| 10 | 160 | 148 | 146 | 135 | 132 | 144 | 142 |
| 11 | 121 | 112 | 110 | 102 | 99 | 109 | 107 |
| 12 | 93 | 86 | 85 | 78 | 75 | 83 | 82 |
| 13 | 75 | 68 | 67 | 61 | 60 | 66 | 65 |
| 14 | 58 | 54 | 53 | 49 | 47 | 52 | 52 |
| 15 | 48 | 44 | 43 | 40 | 39 | 43 | 42 |
| 16 | 39 | 36 | 36 | 33 | 32 | 35 | 35 |
| 17 | 33 | 30 | 30 | 28 | 27 | 30 | 29 |
| L/D | 1.168 | 1.238 | 1.288 | 1.303 | 1.392 | ..... | 1.328 |

K = Number of olives per pound of size 10 multiplied by 1000.
L = Average length of olive.
D = Average thickness of olive or diameter.
L/D = Average ratio of length to thickness.

* The numbers corresponding to diameters 8 and 9 for the Mission were determined by actual weighings of these sizes. The numbers are slightly lower than would be found by calculation, owing to the fact that the undeveloped olives are more elongated than those over 10.

From this table it is possible to find the number of olives required for a pound of the various sizes of the different varieties. The dependence of the number on the ratio of length to thickness, L/D, is clearly shown. Of the Fairoaks variety, which is 1.392 times as long as wide, 257 olives of the 8 sixteenths size weigh one pound, while of the Manzanillo No. 1, which is only 1.168 times as long as wide, 313 of the same size are necessary. The numbers for the smaller sizes 8 to 10, inclusive, are probably a little high. The measurements used to determine the factor K were made on olives ranging from 10 to 16 sixteenths. Olives smaller than this are usually undeveloped and are more elongated than the type. They will, therefore, be heavier in proportion to their diameters and it will require less proportionately to weigh a pound.

The number of size grades which it is *desirable* to separate depends on the objects to be accomplished. The number which it is *possible* to separate depends on the perfection of the grading machine or device used.

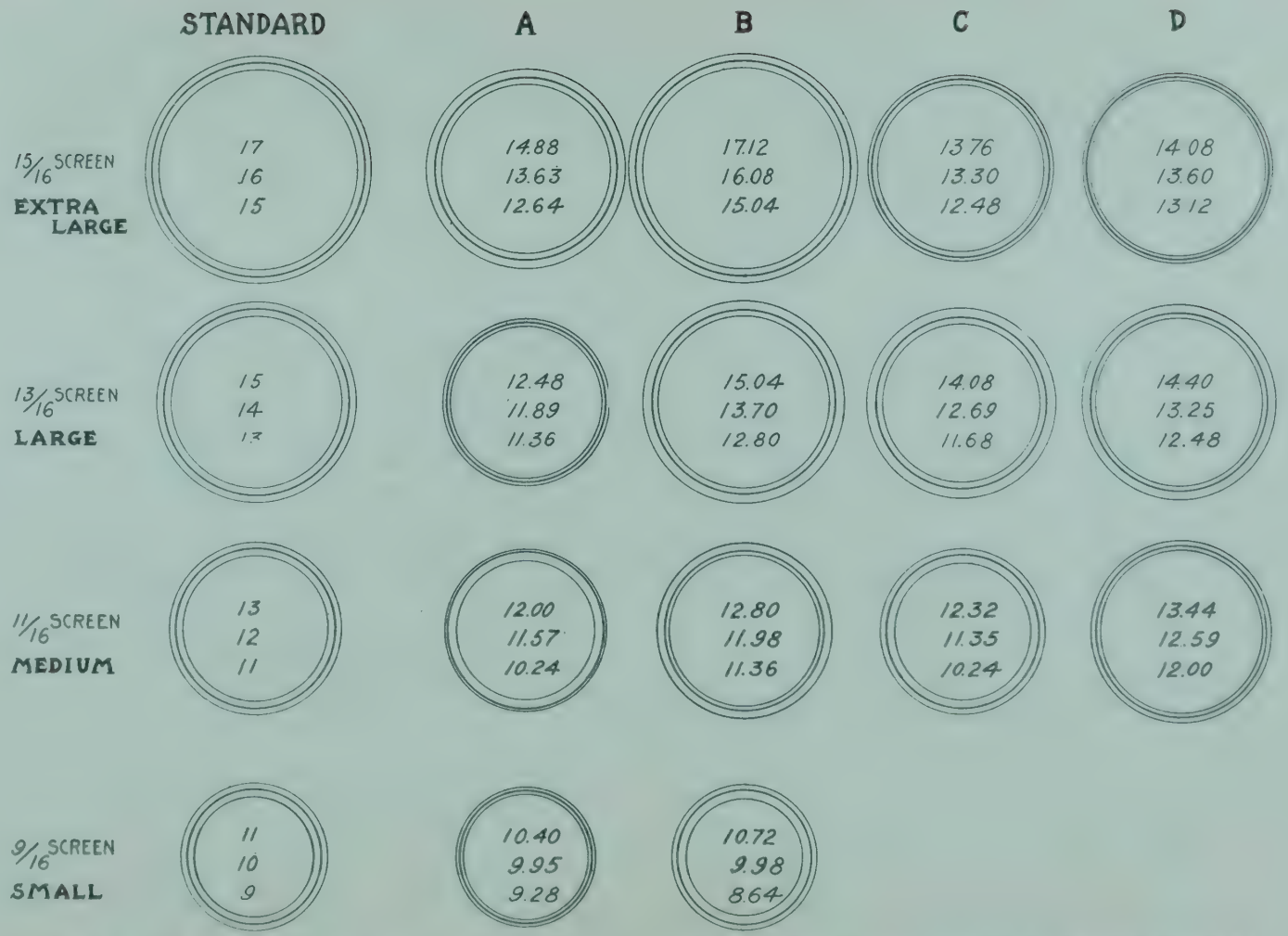


Fig. 1.—A, B, C, D. Maximum, Minimum, and Average diameters of the olives of various grades of four different picklers. *Standard.* Size-grades obtained by using four screens differing by 2 sixteenths of an inch.

In figure 1 is shown in diagrammatic form the sizes and variations found in the various grades of four of the largest picklers of ripe olives in California. A glance at this diagram shows that picklers A and B separate their olives into four fairly distinctive size-grades. Picklers C and D appear not to have had any very large olives and, in grading, probably simply eliminated the fruit that was too small.

Table IV shows the differences between the average sizes of the various grades for each pickler and the range from the largest olive to the smallest.

TABLE IV

DIFFERENCES BETWEEN GRADES (in sixteenths of an inch)

| | Grades | | | | |
|---|---|---|---|---|---|
| | 1–2 | 2–3 | 3–4 | Average | Total range |
| Pickler A | 1.74 | .32 | 1.62 | 1.23 | 5.60 |
| Pickler B | 2.38 | 1.72 | 2.00 | 2.03 | 8.48 |
| Pickler C | .61 | 1.34 | ..... | .98 | 3.52 |
| Pickler D | .35 | .66 | ..... | .51 | 2.08 |

Table V shows the extreme variation in size of olives in each grade for the same picklers.

TABLE V

VARIATIONS IN EACH GRADE (in sixteenths of an inch)

| | Grades | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Average | Total range |
| Pickler A | 2.24 | 1.12 | 1.96 | 1.12 | 1.56 | 5.60 |
| Pickler B | 2.06 | 2.24 | 1.44 | 2.08 | 1.96 | 8.48 |
| Pickler C | 1.26 | 2.40 | 2.08 | ..... | 1.91 | 3.52 |
| Pickler D | .96 | 1.90 | 1.44 | ..... | 1.44 | 2.08 |

The most methodical grading is evidently that of B. Although including a larger range of sizes of olives, the differences between grades and the variations within the grades are more uniform than those of any of the others.

As all sizes of olives between the extremes of the largest and the smallest are likely to occur, the range of variation within each grade should be equal to the difference between the average sizes of two adjacent grades, where the grading is done accurately. This condition is most closely approximated by B, where the range of variation and difference between grades is very close to 2 sixteenths.

It would seem, then, that a difference of 2 sixteenths between grades would be suitable. There is no advantage in having the average

size of two adjacent grades closer than the variation within a grade, as in C and D. This variation exceeded 2 sixteenths with all the picklers except D, and in this case it was very near to this figure.

The grading illustrated in figure 1 under "Standard" is based on this difference of 2 sixteenths.

As the olives are graded before processing, the sizes of the fresh olives indicated in the diagram would not necessarily be exactly the same as those of the pickles, but the difference would be slight. Tests made show that there may be increase in size of a little over 2 per cent.

TABLE VI

INCREASE OF SIZE IN PICKLING

| | Fresh Olives | Pickled Olives | Increase | Variety |
|---|---|---|---|---|
| Sample 1 | 13 sixteenths | 13.36 | = 3% | Manzanillo No. 1 |
| Sample 2 | 13 sixteenths | 13.31 | = 2.4% | Agostino |
| Sample 3 | 13 sixteenths | 13.24 | = 1.9% | Cucco |
| Sample 4 | 11 sixteenths | 11.15 | = 1.4% | Fairoaks |
| | | Average increase | = 2.175 | |

Table VII gives the principal data regarding the standard for size grades which corresponds nearest to the present practice. It divides the olives usually pickled into three size-grades, 1, 2, and 3, called respectively *Extra Large, Large,* and *Medium.* These are all over 11 sixteenths before pickling. The smaller olives, if pickled, could be divided into two other grades, 4 and 5, called *Small* and *Extra Small.* Size 1 would include all olives which failed to pass through a 15 sixteenth screen, size 2 those retained by a 13 sixteenths, and so on. The fourth column gives the approximate average size of the pickled olives and the fifth column the number of pickled olives to the pound, varying according to variety.

TABLE VII

STANDARD FOR SIZE-GRADES

(Based on present practice; difference 2 sixteenths inch)

| | Size | Range | Average | Number per lb. |
|---|---|---|---|---|
| Extra large | 1 | 17–15 | 16 | 32 to 39 |
| Large | 2 | 15–13 | 14 | 47 to 58 |
| Medium | 3 | 13–11 | 12 | 75 to 93 |
| Small | 4 | 11– 9 | 10 | 132 to 160 |
| Extra small | 5 | below 9 | ? | ? |

Table VIII shows the average number per pound for each size for our commonest pickling varieties. The actual sizes of the four grades are shown in figure 1 under "Standard."

TABLE VIII

NUMBER PER POUND OF COMMON VARIETIES WITH THE PRESENT GRADING

| Designation | Retaining screen* | Average diameter* | Average number per lb. | | | |
|---|---|---|---|---|---|---|
| | | | Mission | Sevillano | Ascolano | Manzanillo No. 1 |
| Extra large .... | 15 | 16 | 35 | 33 | 36 | 39 |
| Large ..... | 13 | 14 | 52 | 49 | 54 | 58 |
| Medium ..... | 11 | 12 | 82 | 78 | 86 | 93 |
| Small ..... | 9 | 10 | 142 | 135 | 148 | 160 |

* These numbers represent sixteenths of an inch.

*Proposed Improved Standards.*—It has been proposed to make a closer segregation of sizes than is made by this standard. Some picklers advocate a series of size-grades differing by 1 sixteenth. This would result in an over-lapping of the grades that would be a source of confusion. Olives of the same weight would go into different grades according to their shape. An elongated olive would go into a lower grade than a rounded olive of the same weight. A somewhat flattened olive would go into a higher grade than a round olive of the same weight. There will of course be a certain amount of this over-lapping, whatever the standard adopted, but it will be negligible with a size-difference of 2 sixteenths, but considerable with one of 1 sixteenth.

A more perfect and logical grading would be one that was based, not on an absolute difference of diameter between the size-grades, but on a percentage difference. If the largest grade was the same percentage larger than the second largest, as this was than the third largest, and so on, the result would be a closer grading of the smaller sizes where it is most needed.

For example, an olive with a diameter of 8 sixteenths weighs only 70 per cent as much as an olive of 9 sixteenths, while an olive of 15 sixteenths weighs 82 per cent as much as an olive of 16 sixteenths. In the first case the difference is readily perceptible to the eye; in the other, it is hardly noticeable. A grading based on a percentage difference avoids this difficulty. Such a grading is shown in Table IX.

TABLE IX

PROPOSED STANDARD FOR SIZE-GRADES

(Based on a percentage difference)

| Designation | Retaining screen | Average diameter of Olives | Difference between grades | Average number per lb. | |
|---|---|---|---|---|---|
| | | | | Mission | Other varieties |
| Fancy | 15.0 | 16.0 | ..... | 35 | 32–39 |
| Extra large | 13.2 | 14.1 | 1.9 | 51 | 46–57 |
| Large | 11.6 | 12.4 | 1.7 | 75 | 68–83 |
| Medium | 10.2 | 10.9 | 1.5 | 111 | 100–124 |
| Small | 9.0 | 9.6 | 1.3 | 162 | 146–180 |

By this method the difference between grades gradually increases from 1.3 sixteenths between the smallest grades to 1.9 sixteenths between the largest. Each grade has almost exactly 88 per cent the average diameter of the next larger grade and weighs 68 per cent as much. The number of olives to the pound would be inversely proportionate to the weight and the number for each grade would be 68 per cent of the next smaller grade.

This method of dividing the size-grades would, from many points of view, be preferable to those now in use. It apears to be as close a grading as is possible in view of the irregularity in the shape of olives of all varieties. It would insure a closer grading than the present system. Olives about 9 sixteenths would be separated into five size-grades, instead of into four, as is the present custom.

## PROPOSED SIZE-GRADES FOR OLIVES

1. *Fancy.* All which are retained by a screen of 15 sixteenths mesh. Average diameter of olives, about 16 sixteenths. Average weight for Mission variety, 35 to the pound.

2. *Extra Large.* All which pass a 15 but fail to pass a 13.2 sixteenths mesh. Average diameter of olives, 14.1 sixteenths. Average weight for Mission, 51 to the pound.

3. *Large.* All which pass a 13.2 but fail to pass an 11.6 sixteenths mesh. Average diameter of olives, 12.4 sixteenths. Average weight for Mission, 75 to the pound.

4. *Medium.* All which pass an 11.6 sixteenths, but fail to pass a 10.2 sixteenths mesh. Average diameter of olives, 10.9 sixteenths. Average weight for Mission, 111 to the pound.

5. *Small.* All which pass a 10.2 sixteenths, but fail to pass a 9 sixteenths mesh. Average diameter of olives, 9.6 sixteenths. Average weight for Mission, 162 to the pound.

Some of the best size-grading machines for olives do not make use of perforated screens but of tapering or adjustable slots. It is possible to adjust such a grader to any standard of sizes. Some picklers adjust the grader so that it divides the olives into size-grades having each a specified number of olives per pound.

In one factory four size-grades are made, having respectively 60, 72, 90, and 120 olives to the pound. For Mission olives these numbers represent average diameters of 13.3, 12.4, 11.6, and 10.6 sixteenths, or

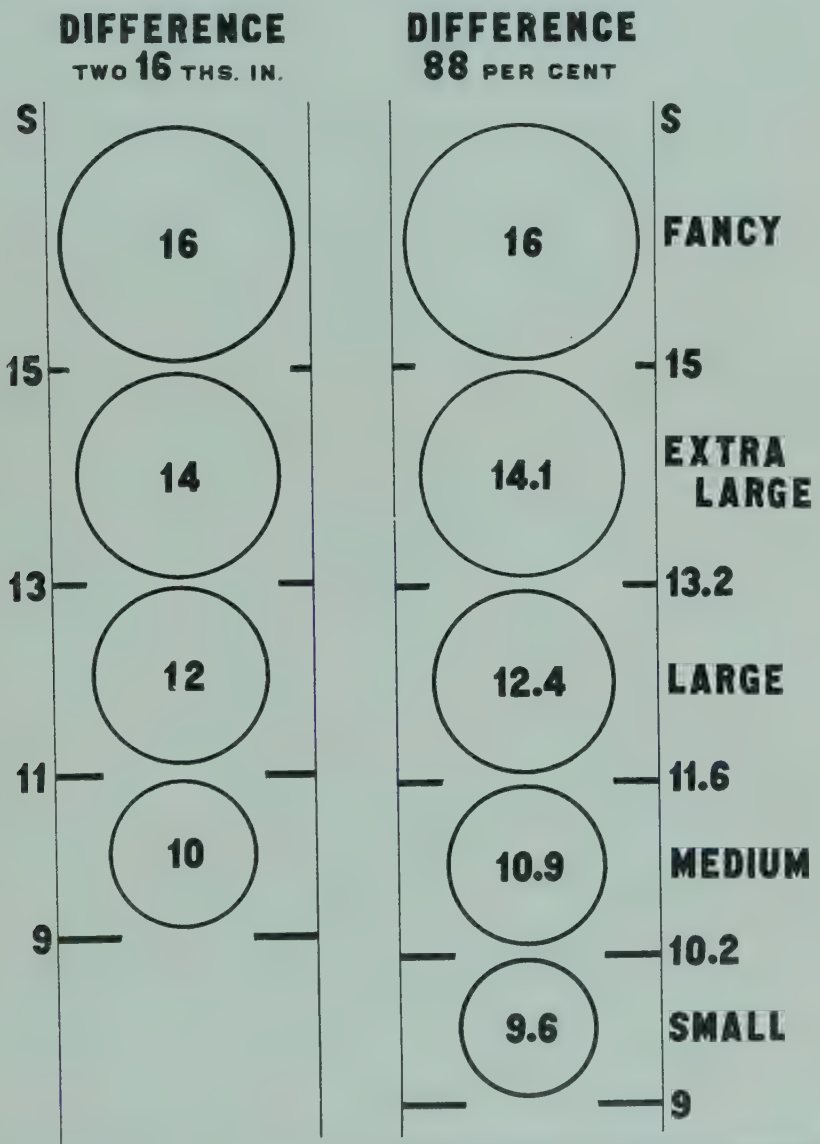


Fig. 2.—Comparison of the most usual present system with the proposed system.
Right column: Four size-grades of most common present system.
Left column: Five size-grades of proposed percentage system.
The numbers in the circles show the average diameter of the olives; the numbers at each side show the diameter of the holes in the sorting screens.

the grading that would be obtained by screens of 10, 11, 12, and 13 sixteenths of an inch. The objections to this close grading have already been shown, and also to the adoption of an absolute difference instead of a percentage difference.

## COMPARISON OF VARIOUS SYSTEMS OF SIZE-GRADING

A. Size-grades differing by 2 sixteenths of an inch.

B. Size-grades differing by 88 per cent in diameter and 68 per cent in weight.

C. Nearest approximation to system B that can be made with screens differing by thirty-seconds of an inch.

DIAMETER OF PERFORATIONS OF SCREENS (in sixteenths of an inch)

| | | | | | |
|---|---|---|---|---|---|
| A | 15 | 13 | 11 | ..... | 9 |
| B | 15 | 13.2 | 11.6 | 10.2 | 9 |
| C | 15 | 13 | 11.5 | 10 | 9 |

DIAMETER AND WEIGHT OF OLIVES OF EACH GRADE

| Average diameter | | | Olive Grades | No. of Olives per lb. | | |
|---|---|---|---|---|---|---|
| A | B | C | | A | B | C |
| 16 | 16 | 16 | Fancy | 35 | 35 | 35 |
| 14 | 14.1 | 14 | Extra large | 52 | 51 | 52 |
| 12 | 12.4 | 12¼ | Large | 82 | 75 | 77 |
| 10 | 10.9 | 10¾ | Medium | 142 | 111 | 114 |
| .... | 9.6 | 9½ | Small | ..... | 162 | 166 |
| <9 | 9 | 9 | Culls | ..... | ..... | ..... |

## SUMMARY AND CONCLUSIONS

1. The separation of olives into size-grades is necessary for the best results in pickling and marketing.

2. No standard has been established for size-grades.

3. There is much lack of uniformity in present practice.

4. Some picklers simply eliminate all small olives, usually those whose shortest diameter is less than 10 or 11 sixteenths. Other picklers divide the olives above 9 sixtenths into three or four grades differing by 2 sixteenths.

5. Some picklers consider that this grading is not fine enough and advocate grades differing by only 1 sixteenth.

6. A difference of 1 sixteenth is unnecessarily fine, as adjoining grades would be almost indistinguishable, especially with the larger

sizes. This small difference is also impracticable owing to irregularities in the shape of the olives.

7. A grading based on any absolute difference between all sizes is imperfect. If suitable to the larger sizes, it will be too coarse for the smaller; if suitable for the smaller, it will be too fine for the larger.

8. A more suitable grading would be one based on a percentage difference; one in which each size was a certain per cent of the next larger size.

9. A grade based on a difference in diameter of 88 per cent is proposed. This would increase the number of size-grades above 9 sixteenths from four, which is usual now, to five. It would decrease the absolute difference between the smallest sizes to 1.3 sixteenths, while that between the largest sizes would be 1.9 sixteenths.

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# THE CALIBRATION OF THE LEAKAGE METER

FUMIGATION STUDIES No. 8

BY

C. W. WOODWORTH

GOVERNMENT
SEP 6 1916
BUREAU OF ECONOMIC ENTOMOLOGY
LAL-BAGH, BANGALORE

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# THE CALIBRATION OF THE LEAKAGE METER

By C. W. WOODWORTH

Some of the leakage meters put on the market prove to have been incorrectly calibrated and indicate excessive leakages. This has not been serious as long at the instruments have been used only for the comparison of samples of tent materials, but they should be corrected to suit them, for use in connection with dosage tables. This is easily done by using a reamer on the small opening from the brass tube to to the small chamber behind the cloth under the clamp. It requires very skillful work, however, and it is wise to return to the manufacturer for adjustment any meters that do not register correctly.

The present publication is intended to enable users of these instruments to determine approximately the correctness of this adjustment. The theory of the meter is that if two test plates were used to correspond with the two thicknesses of cloth to be tested then the diameters of the test plates would bear such a relation to the diameter of the sharp edge of the clamp that the areas of the smaller circle in the test plate should be between .20 and .25 per cent of the area of the larger circle of the clamp and precisely the amount shown by the test line on the meter. Instead, however, of using two test plates a single plate with a smaller hole of exactly the right size to make the same reading on the meter is furnished with the instrument. The smaller hole is just 84 per cent of the diameter that would give the right calculation of percentages of leakage through the doubled cloth, therefore for making calculations the diameters of the test plates must be increased.

The testing of the meter consists in measuring the size of the ring of the clamp and of the hole in a test plate and finding whether or not the actual test corresponds with the percentages calculated from the measurements of these sizes. Accurate testing requires very careful work but it is very easy to make a test sufficiently accurate to determine whether the instrument shows gross errors.

## MEASURING THE CLAMP

The best way to measure the clamp is to use a piece of cardboard with which to take an impression of the ring, putting in several thicknesses, if necessary, to obtain a clear, sharp mark. After obtain-

ing the impression measure this carefully with a finely divided rule determining the nearest 64th of an inch. The size will be found to be approximately $\frac{5}{8}$ or $\frac{40}{64}$ths of an inch and the table below gives readings for possible variations for a sixteenth of an inch in either direction. A 64th of an inch variation modifies the reading by less than .02 of a per cent.

## MEASURING THE TEST PLATE

The hole in the test plate is very much more difficult to measure accurately. The standard wire gauge known as the "Brown and Sharpe" gauge is to be had in every machine shop and is perhaps the most accurate measure for this purpose. Lay this on the test plate and examine it under a pocket lens. The hole should appear as shown in figure 1. Another method is to make a test plate by the use of an

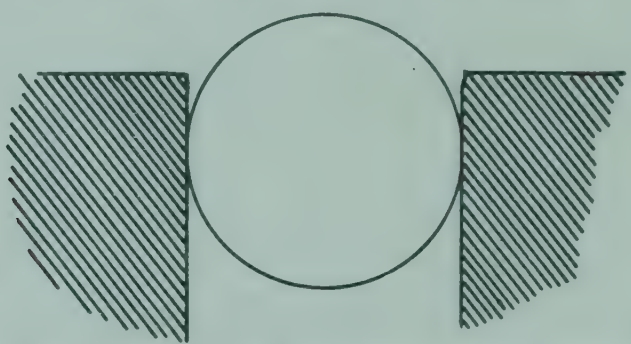

Fig. 1.—The way the hole in the test plate should appear under the wire gauze as seen through the microscope.

ordinary sewing needle. This method will probably prove more accurate with most people than the use of a wire gauge because of the practical difficulty of making the comparisons under the microscope. The best test plates made in this manner are with soft metal, like copper, lead or zinc. A very thin sheet of these metals can be very easily perforated. Fair results can be secured by using a piece of good quality writing paper or cardboard. The fiber in the softer cardboard swells out and partially closes the hole and so gives low readings. If it is found that a needle fits tightly in a hole after withdrawing it a few minutes it is not suitable.

A very good method is found to consist in perforating a sheet of celluloid in rather hot water, then placing the celluloid in cold water and leaving the needle in position until the celluloid is cool. The hole under these circumstances proved almost if not quite as good as in metal.

In all cases thrust the needle through to the middle so as to have the full width of the shaft.

The use of the needle is so simple and convenient that it will probably be the most satisfactory method in practice to make a new test plate rather than to attempt to measure the one furnished with the instrument.

## MAKING THE TEST

The test plate is clamped in the instrument and the reading carefully made in the same manner as in testing tent material.

Comparing this with the calculation given in the table in the column under the diameter of the hole in the test plate and the line of the diameter of the clamp ring enables one to determine the per cent of error. When the table values differ from the determined value the error is approximately 6 per cent for each line. The difference of adjacent columns is approximately four times as great.

One degree on the meter between .15 and .20 corresponds with about six lines, between .20 and .25 four lines and from .25 to .35 about three lines. If the observed error is greater than this, the instrument should be sent to the maker for adjustment, and perhaps even for a lesser error, rather that to try to adjust by reading "strong" or "weak."

## TABLE FOR TESTING LEAKAGE METERS

| | | | | | | |
|---|---|---|---|---|---|---|
| Wire gauge No. | 20 | 21 | 22 | 23 | 24 | 25 |
| Needle No. | 5 | 6 | 7 | 8 | 9 | 10 |
| Diameter | .032 | .028 | .025 | .022 | .020 | .018 |
| Augmented | .038 | .033 | .030 | .026 | .024 | .021 |

| *Diameter of clamp* | | | *Correct meter readings × 100* | | | | |
|---|---|---|---|---|---|---|---|
| 36–64ths | .564 in. | 14.3 mm. | ..... | 35 | 28 | 21.7 | 17.9 | 14.5 |
| 37 | .580 | 14.7 | ..... | 33 | 26.4 | 20.4 | 16.9 | 13.6 |
| 38 | .595 | 15.1 | ..... | 31.5 | 25.0 | 19.5 | 16.0 | 13.0 |
| 39 | .610 | 15.5 | 39.0 | 29.8 | 23.8 | 18.5 | 15.3 | 12.4 |
| 40 | .625 | 15.9 | 37.0 | 28.5 | 22.7 | 17.6 | 14.6 | 11.7 |
| 41 | .642 | 16.3 | 35.0 | 26.9 | 21.5 | 16.7 | 13.8 | 11.2 |
| 42 | .658 | 16.7 | 33.3 | 25.6 | 20.5 | 15.9 | 13.1 | 10.6 |
| 43 | .672 | 17.1 | 32.0 | 24.5 | 19.6 | 15.2 | 12.6 | 10.1 |
| 44 | .688 | 17.5 | 32.5 | 23.5 | 18.7 | 14.5 | 12.0 | ..... |

## CALCULATION OF THE TABLE

While it is not necessary to make any calculations to test a meter it will be well to explain the calculation of the above table.

The easiest method of doing this is by the use of a slide rule. the settings of which are as follows:

$$\frac{C}{D}\frac{21}{25} = \frac{C}{D}\frac{\text{needle diameter}}{x} \qquad \frac{C}{D}\frac{\text{clamp diameter}}{x} = \frac{A}{B}\frac{y}{1}$$

x = augmented needle diameter to allow for doubled tents.
y = correct meter readings of per cent of leakage.

## SUMMARY

Some leakage meters are so inaccurate that they are unsuitable for use as guides to dosage.

The accuracy can be easily tested by measuring the clamp ring and the hole of the test plate.

Needles can be used to make test plates making their measurement unnecessary. The amount of the inaccuracy is determined by comparing the reading with a table. If found inaccurate the instrument should be returned to the maker for adjustment.

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# GROWING AND GRAFTING OLIVE SEEDLINGS

## PART I. GROWING OLIVE SEEDLINGS

BY

F. T. BIOLETTI AND W. F. OGLESBY

## PART II. GRAFTING OLIVE SEEDLINGS

BY

F. T. BIOLETTI AND F. C. H. FLOSSFEDER

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BENJAMIN IDE WHEELER, President of the University.

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*In co-operation Office of Public Roads and Rural Engineering, U. S. D. A.

# PART I.—GROWING OLIVE SEEDLINGS

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Olives are propagated by three general methods: by herbaceous or "tip" cuttings, by woody cuttings, and by seeds and grafting. The first method is used extensively by California nurserymen, but requires costly equipment of propagating beds and heating apparatus with considerable skill and experience. The second is most commonly used by European and Asiatic growers, and by all except skilled nurserymen. It is often, however, difficult to obtain cuttings of proper size in quantity, and some varieties root with difficulty. Trees started from woody cuttings, moreover, seem particularly subject to root and stem rot. The third method is used to a limited extent by California nurserymen and is highly recommended by most European authorities.

It is claimed that trees grown from grafted seedlings are more productive, healthier, and longer-lived than those grown from any form of cutting. That they are more productive is indicated by what little evidence we have on this matter in California. The objections made against the use of seedlings are that it takes a longer time to bring a tree to bearing age and that the germination of the seeds and the grafting of the seedlings are difficult and uncertain.

Some preliminary experiments made by this station indicate that it is possible to produce grafted trees just as quickly as trees from cuttings and by methods easily applied by any grower. This bulletin gives the results obtained in tests to determine:

I. (*a*) A method of separating good seed from poor.
   (*b*) The best preliminary treatment of seed to facilitate germination.
   (*c*) The best conditions of planting to promote quick and uniform germination.

II. A good method of nursery grafting.

## A. SEPARATION OF GOOD SEED FROM POOR SEED

Seeds of various varieties were obtained from different localities. An examination of these seeds showed that many of them were empty or contained imperfect kernels. In some samples, nearly all the seeds were good; in others nearly half were poor, and nearly all showed

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## A. SEPARATION OF GOOD SEED FROM POOR SEED

Seeds of various varieties were obtained from different localities. An examination of these seeds showed that many of them were empty or contained imperfect kernels. In some samples, nearly all the seeds were good; in others nearly half were poor, and nearly all showed

various percentages of imperfect seeds. By breaking their shells and examining the kernels, the proportion of good to poor was determined for a number of samples with the results shown in Table I.

TABLE I

RATIOS OF GOOD TO POOR SEED

| No. of test | No. of seeds | Good seed, per cent | Poor seed, per cent |
|---|---|---|---|
| 1. Pendulina; Niles, Alameda Co. | 50 | 100.0 | .0 |
| 2. Redding; Davis, Yolo Co. | 100 | 99.0 | 1.0 |
| 3. Medium sized olives; Tehama Co. | 24 | 96.0 | 4.0 |
| 4. Small sized olives; Tehama Co. | 61 | 91.8 | 8.2 |
| 5. Mission; Davis (1913), Yolo Co. | 38 | 89.5 | 10.5 |
| 6. Picholine d'Aix; Niles, Alameda Co. | 36 | 86.1 | 13.9 |
| 7. Mission; Davis (1914), Yolo Co. | 100 | 86.0 | 14.0 |
| 8. Redding; Fresno | 709 | 85.2 | 14.8 |
| 9. Rubra; Niles, Alameda Co. | 40 | 85.0 | 15.0 |
| 10. Atro Rubens; Niles, Alameda Co. | 50 | 80.0 | 20.0 |
| 11. Columella; Niles, Alameda Co. | 100 | 79.0 | 21.0 |
| 12. Polymorpha; Niles, Alameda Co. | 50 | 78.0 | 22.0 |
| 13. Oblonga; Corning, Tehama Co. | 27 | 74.0 | 26.0 |
| 14. Regalis; Niles, Alameda Co. | 50 | 66.0 | 34.0 |
| 15. Seedling; University Campus | 550 | 60.5 | 39.5 |
| 16. Razzo; University Campus | 250 | 54.0 | 46.0 |

Percentage of good seed: Maximum, 100%. Minimum, 54%. Average, 81.9%.

This table indicates that the percentage of viable seeds differs with the variety, with the locality and with the season. Pendulina from Niles showed 100 per cent of good seed, while Regalis from the same locality showed only 66 per cent. Redding from Davis showed 99 per cent, while the same variety from Fresno showed 85.2 per cent; Mission from Davis in 1913 showed 89.5 per cent and in 1914, 86 per cent. The common belief that the seeds of the Mission contain imperfect kernels is evidently not true in all cases.

In order to obtain a true comparison in the germinating tests a method was sought of separating the good seed from the poor. Such a method would be of value also to the propagator, as it would enable him to avoid the useless handling of worthless seed. As the good seed is of higher specific gravity, it was possible to separate it from the poor by means of a solution of common salt. The good, heavy seed sank, and the light, worthless seed floated.

It is necessary that the salt solution be of the proper strength. If too strong many good seeds will float and be lost and if too dilute many poor seeds will sink and fail to be eliminated. The proper

concentration of the salt solution depends on the condition of the pits. If the pits are used as soon as they are cleaned from the pulp, an almost perfect separation is obtained by the use of a 25 per cent solution, that is, a brine made by dissolving 25 parts of salt in 100 parts of water by weight. If the pits are dried for several weeks, a 10 per cent solution gives the best results. If the dried seeds are soaked in water for two days they can be separated satisfactorily in a 25 per cent solution. If soaked for a long time—fifteen days—the poor seed becomes as heavy as the good and cannot be separated. The seeds of a few varieties, such as the Mission, with exceptionally thick, heavy shells require a still more concentrated solution. Redding seed and all varieties with small seeds which were tested were separated well in a 25 per cent solution. Table II shows the results obtained in separating the fresh seed of various varieties in a 25 per cent brine.

TABLE II

SEPARATION OF GOOD SEED FROM POOR IN 25 PER CENT BRINE

| No. of test | No. of seeds used | Per cent of good seeds | No. that sank | | No. that floated | | Per cent of good seed retained | Per cent good in seed retained |
|---|---|---|---|---|---|---|---|---|
| | | | Good | Poor | Good | Poor | | |
| 1. Pendulina; Niles | 50 | 100 | 47 | .... | 3 | .... | 94 | 100 |
| 2. Redding; Davis | 50 | 98 | 49 | *1 | .... | .... | 100 | 98 |
| 3. Medium sized olive; Corning | 24 | 96 | 23 | *1 | .... | .... | 100 | 96 |
| 4. Small olive; Corning | 61 | 92 | 56 | *1 | .... | 4 | 100 | 92 |
| 5. Pich. d'Aix; Niles | 36 | 86 | 31 | .... | .... | 5 | 100 | 100 |
| 6. Rubra; Niles | 40 | 85 | 33 | *1 | 1 | 5 | 94 | 94 |
| 7. Atro Rubens; Niles | 50 | 80 | 40 | *3 | .... | 7 | 100 | 93 |
| 8. Columella; Niles | 100 | 79 | 78 | *2 | 1 | 19 | 99 | 98 |
| 9. Polymorpha; Niles | 50 | 78 | 39 | *1 | .... | 10 | 100 | 98 |
| 10. Oblonga; Corning | 27 | 74 | 20 | *2 | .... | 5 | 100 | 91 |
| 11. Regalis; Niles | 50 | 66 | 33 | *2 | .... | 15 | 100 | 94 |
| 12. Seedling; U. C. Campus | 100 | 58 | 58 | *8 | .... | 34 | 100 | 88 |
| 13. Razzo; U. C. Campus | 50 | 54 | 27 | *2 | .... | 21 | 100 | 93 |

*Very small seed.

| | |
|---|---|
| Good kernels in seed before separation | 78.3% |
| Good kernels in seed after separation | 95.7% |
| Good kernels lost in separation | .93% |
| Poor seed eliminated | 81.2% |

From this table it will be seen that before separation, an average of 21.7 per cent of all the seed was worthless. After separation, of the seed recovered, only 4.3 per cent was poor. Less than 1 per cent of

the good seed was lost and over 80 per cent of the poor seed was eliminated.

The high specific gravity of the few bad seeds which sank was due to the fact that they were solid to the center with no apparent kernel cavity. They were all much smaller than the normal seeds and would be removed by screening. Separation by immersion in brine, followed by removal of small seeds by screening, would therefore be practically perfect.

Most of the germination tests were made with Redding[1] seed, as this variety seems particularly suitable for a stock. The percentage of viable seeds was high in all cases and in some cases there was practically no bad seed. Where seed of this variety is used the main use of the brine test would be to determine the quality of the seed as a whole, in order to decide whether the sample was suitable for planting, as our observations indicate that where a large percentage are not viable even those which germinate produce weak plants.

### B. PRELIMINARY TREATMENT OF THE SEED

If olive seeds are planted either with or without the pulp and without treatment, most of them do not germinate for a year or more. This appears to be due to the oil present and to the thick woody pit, which delay the penetration of water, without which the seeds cannot germinate.

The usual method of handling the seeds is to "stratify" them for about sixteen months and then to plant either in "flats" or directly in the nursery. Two methods of stratification are used. In one, the olives are mixed with sand and placed in a box or pit. They are kept moist continuously from about December until March of the second spring following, when they are planted in the flats. Another method is to plant the seeds about an inch apart in a box or bed and keep them moist until they germinate and grow several inches. This will take nearly two years. They are then transplanted to flats or directly into the nursery. There is a loss of a whole year in each case.

Various methods have been recommended for hastening the germination of olive seeds. All of them are attempts to increase the permeability of the seed to water by removing the oil or by softening or breaking the stone. Among these are soaking in warm water or in alkaline or acid solutions, feeding the olives to turkeys and using them after they have passed through the digestive tract, and cracking the stones in a vise.

[1] Usually known by the misleading name of "Redding Picholine."

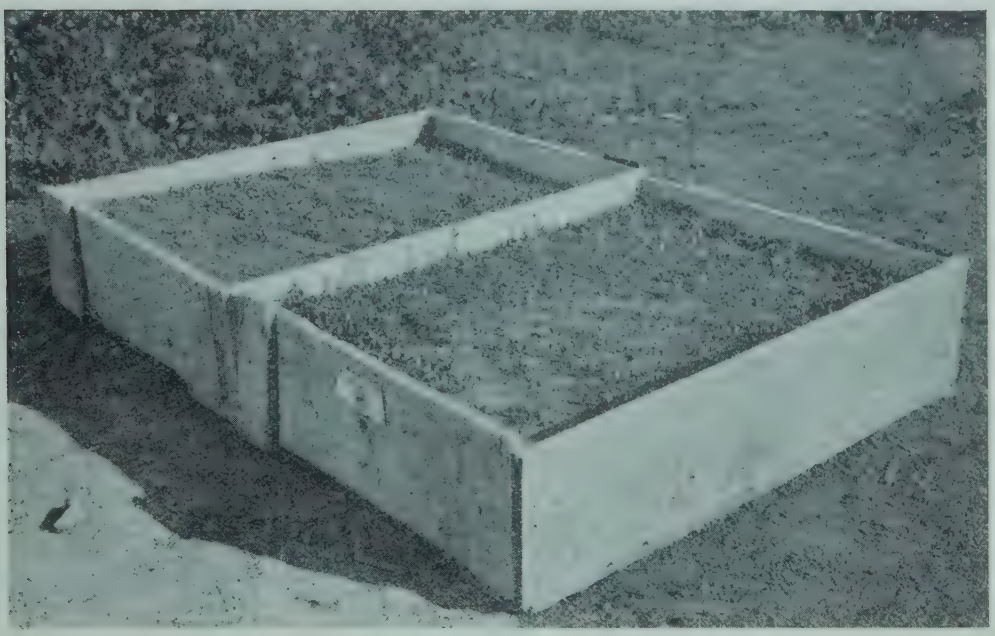


Fig. 1.—Redding olive seeds sprouting in a large box. These seeds were stratified by the first method in December, 1912, and left until April, 1914, when they were planted in the box shown. The photograph was taken twenty months after the seed was gathered.

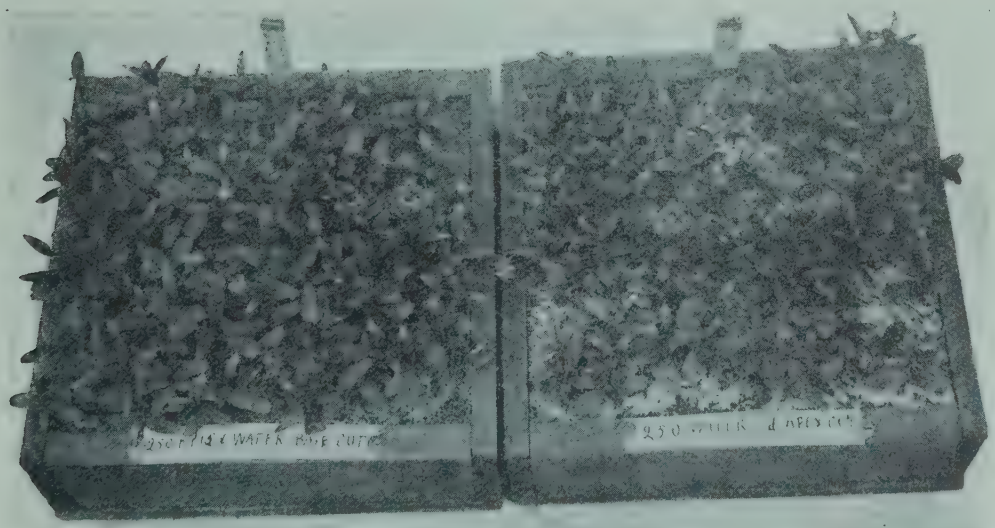


Fig. 2.—Redding olive seeds sprouting in 4-in. flats. These seeds were clipped in March, 1913, and planted in the flats as shown. The photograph was taken in August, 1913, five months after the seeds were gathered, showing a gain of more than fifteen months over the stratifying method.

In order to test the most promising of these methods, several series of experiments were made. In the first, pits of a small-fruited seedling growing in the University grounds were used. By examination it was found that only 60.5 per cent of the pits had apparently perfect kernels (see No. 15, Table I). The light seed was removed by means of a 25 per cent salt solution, the proportion of good seed being thus increased to 88 per cent (see No. 12, Table II). The experiments included soaking in water and in various solutions. Breaking or cracking the shell of the pit by means of a vise was found too slow and by use of a hammer too many were broken. It was found possible, however, to cut off a piece of the shell by means of a specially designed pincer rapidly and without injury to the seed. Experiments based on this method were also included.

The seeds, after being separated in the salt solution, were divided into thirteen lots and treated as indicated in Table III.

The various lots were all planted on March 18, 1913, directly after treatment. They were placed in the greenhouse in shallow boxes containing a mixture of three parts sand and one part garden loam. They were put in about half an inch deep, the soil firmed and kept moist at all times. The germination results are given in Table III.

TABLE III

EFFECT OF PRELIMINARY TREATMENT OF SEED ON GERMINATION

| No. of test | Treatment | No. used | Number sprouting | | | Per cent sprouting of | | |
|---|---|---|---|---|---|---|---|---|
| | | | June 1 | July 1 | Aug. 16 | Good seed | Seed planted | Original seed |
| 1. | Soaked and apex clipped | 250 | 32 | 98 | 121 | 55 | 48 | 29 |
| 2. | Soaked and base clipped | 250 | 6 | 59 | 110 | 50 | 44 | 27 |
| 3. | Dry seed, apex clipped | 125 | 24 | 46 | 55 | 50 | 44 | 27 |
| 4. | Dry seed, notch filed | 50 | 1 | 6 | 18 | 41 | 36 | 22 |
| 5. | Dry seed, base clipped | 150 | 12 | 39 | 40* | 30 | 27 | 16* |
| 6. | 1 hr. 10% $H_2SO_4$ | 200 | 2 | 23 | 48 | 27 | 24 | 15 |
| 7. | 16 hrs. 10% KOH | 100 | 0 | 2 | 21 | 24 | 21 | 13 |
| 8. | Untreated—dry | 250 | 4 | 11 | 45 | 20 | 18 | 11 |
| 9. | Soaked 15 days | 2075 | 1 | 62 | 360 | 19 | 17 | 10 |
| 10. | 30 min. strong $H_2SO_4$ | 200 | 2 | 13 | 27 | 15 | 14 | 8 |
| 11. | 42 hrs. in lime paste | 50 | 0 | 0 | 5 | 11 | 10 | 6 |
| 12. | 8 hrs. 10% KOH† | 100 | 1 | 4 | † | .... | .... | .... |
| 13. | Pulp not removed | 100 | 0 | 0 | .... | .... | .... | .... |

* Some of the seedlings of No. 5 were lost by damping off.

† Experiment lost.

These results indicate that not only was there a large proportion of obviously imperfect seed in the original fruit, but that even the separated and apparently perfect seed had low germinating power. After

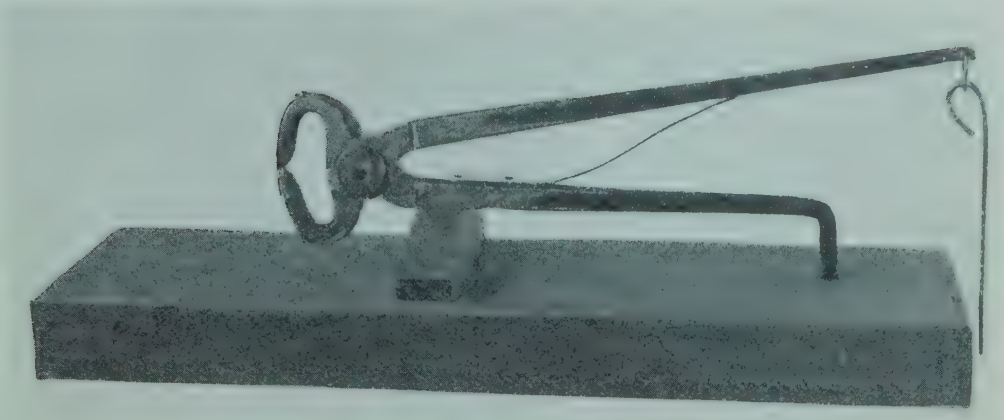


Fig. 3.—Side view of clipper.

five months the highest per cent of germination obtained was 29 per cent of the original seed, 48 per cent of the separated seed, and 55 per cent of that which appeared to be perfect on inspection. Later tests indicate that the seed was planted too deep and kept too wet. The varying percentages of germination, however, are probably a fair measure of the utility of the various methods of preliminary treatment. They indicate that soaking in water for fifteen days, in 10 per cent

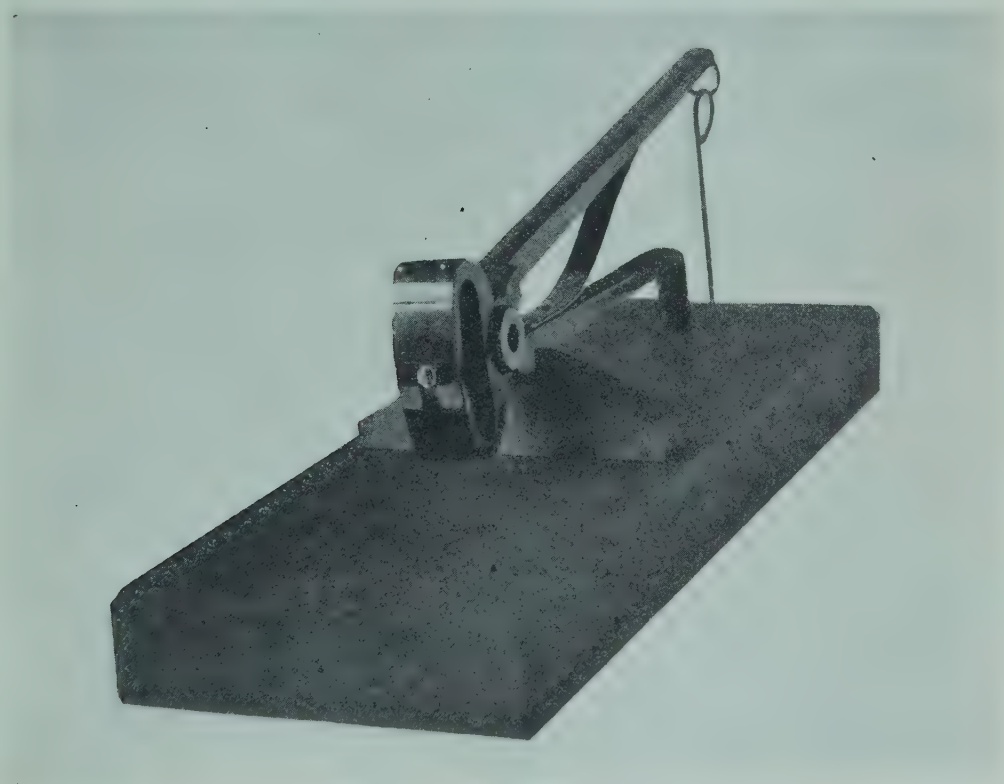


Fig. 4.—End view of clipper.

sulfuric acid for one hour, or in 10 per cent caustic potash for sixteen hours, does little or no good. Soaking in strong sulfuric acid for thirty minutes or in lime paste for forty-two hours appears to be injurious. Clipping the shell of the pit, on the other hand, increased the number of seedlings obtained from two to three times.

Fig. 5.—Redding seeds clipped.

Another series of experiments was made with Redding seed of high germinating power. These by examination showed 99 per cent of apparently perfect kernels. After separation in salt solution, the proportion of good seed was practically the same. Three experiments were made as follows:

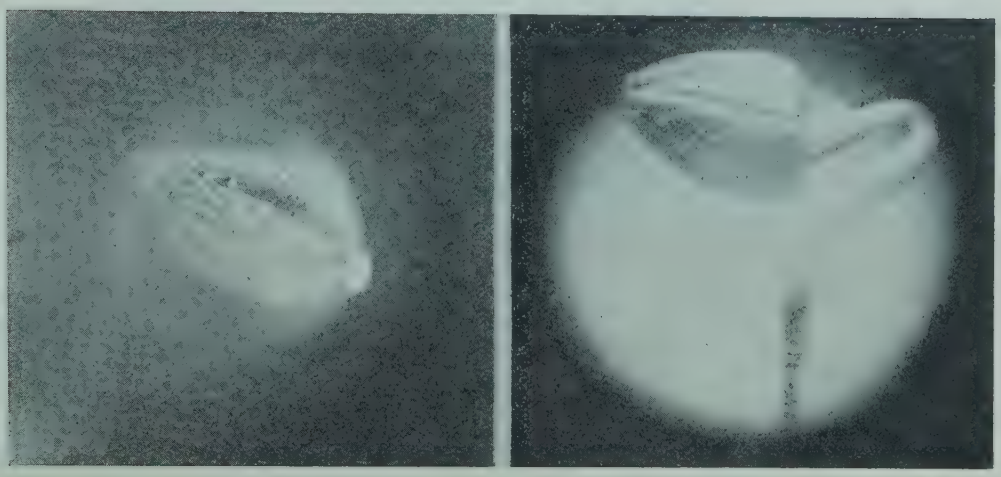
TABLE IV

EFFECT OF CLIPPING SEED

| No. of test | Treatment—March | No. used | Number sprouted | | | | Per cent sprouted |
|---|---|---|---|---|---|---|---|
| | | | May 1 | June 1 | July 1 | Aug. 1 | |
| 1. | Apex clipped | 250 | .... | 48 | 166 | 221 | 88.4 |
| 2. | Base clipped | 250 | .... | 24 | 84 | 200 | 80.0 |
| 3. | Untreated | 200 | .... | 1 | 17 | 60 | 30.0 |

The utility of clipping the seed was well demonstrated in this series.

*Seed Clipper.*—The device finally adopted for clipping the seed was made from a pair of "farriers' nippers," fourteen inches long with a



*a* *b*

Fig. 6.—Germination of olive seed clipped at the apex.

one-inch jaw. This was mounted on a board, as illustrated in figure 3. A spring between the handles kept the jaws open. The point of the pit was clipped by inserting it between the jaws and then closing them by pressing with the foot on a wire loop attached to the upper handle. In order to prevent the pit being inserted too far, a shield consisting

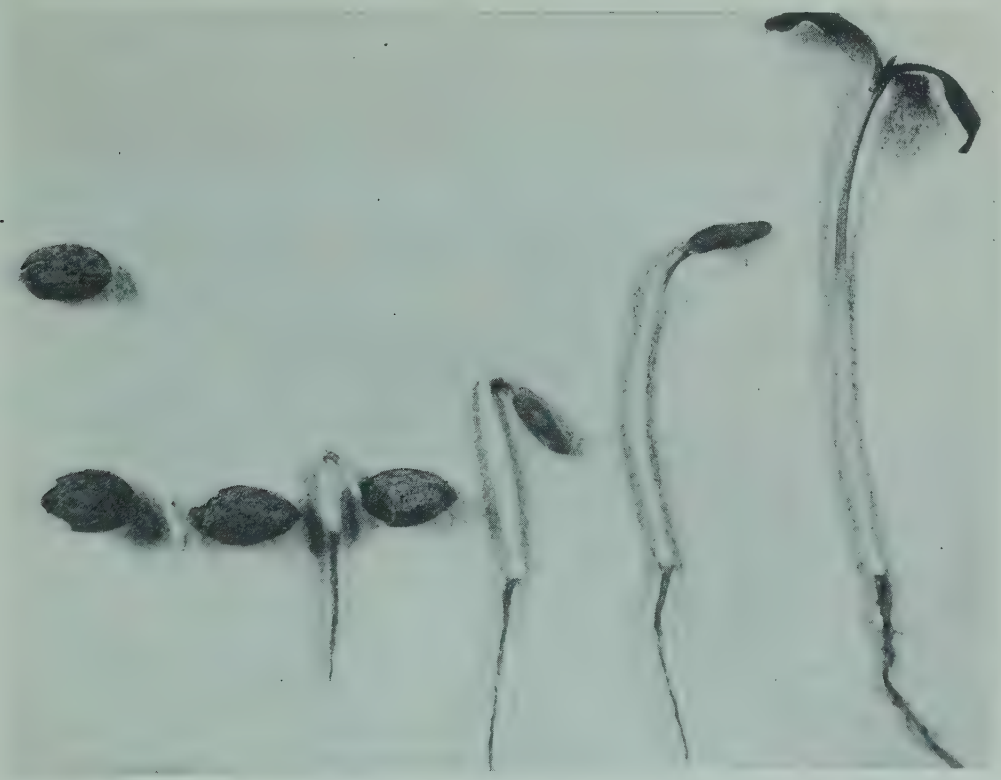


Fig. 7.—Stages in the germination and growth of an olive seedling.

of a thin piece of brass was rivetted to the immovable upper jaw. In this shield a slot was cut $\frac{9}{32}$ of an inch wide for the insertion of the pit. To prevent cutting the kernel, a rounded notch was filed in each jaw, forming when closed a hole $\frac{3}{16}$ of an inch in diameter vertically and $\frac{3}{16}$ horizontally. This hole is not circular as it appears in figure 4.

This clipper is suited for small seeds, such as those of the Redding, which seems the most suitable for the purpose of any variety available in California.

The work of clipping with this machine is easily and rapidly done. From 1200 to 1500 seeds per hour can be clipped with very little practice. The appearance of the seeds after clipping is shown in figure 5.

By reference to Tables III and IV it will be seen that a somewhat larger percentage of germination was obtained where the apex or pointed end was clipped than where the clipping was done at the base. The superiority in rapidity of germination is even more marked than the total number.

The probable reason of this superiority is shown by figure 6, *a* and *b*. This shows that the radicle or germinating point of the seed lies at the apical end and that when the shell is removed from this end it emerges and penetrates immediately into the soil. When the base is clipped the radicle cannot emerge until the pit splits. Various stages in the germination and growth of the seedling are shown in figure 7.

*Treatment with Hot Water.*—The germination of many seeds is facilitated by a preliminary immersion in hot water. The effect of this treatment on olive seed is shown in Table V.

TABLE V

EFFECT OF TREATMENT WITH HOT WATER

(100 Redding seeds from Davis in each test; planted Feb. 19, 1915)

| No. of test | Treatment | Number sprouting | | | |
|---|---|---|---|---|---|
| | | May 1 | June 1 | July 1 | Aug. 16=total % |
| 1. | Soaked 48 hrs. water 40° C. | 0 | 10 | 20 | 32 |
| 2. | Soaked ¼ hr. water 55° C. | 1 | 23 | 28 | 35 |
| 3. | Soaked 1 hr. water 55° C. | 15 | 17 | 24 | 30 |
| 4. | Soaked 1 hr. water 60° C. | 0 | 1 | 1 | 1 |
| 5. | Soaked ¼ hr. water 60° C. | 6 | 24 | 27 | 44 |
| 6. | Soaked 48 hrs. water cold | 5 | 18 | 27 | 43 |
| 7. | Untreated | 1 | 17 | 24 | 40 |

Soaking for one hour in water of 60° C. (140° F.) evidently killed most of the seed (Test 4). The differences between the final results of the other tests and of the untreated seeds are slight and perhaps within

the limits of experimental error. Soaking in cold water for two days or in hot water for a short time apparently hastens germination. This acceleration of germination is most noticeable in No. 3, where the seed was soaked for one hour in water at 55° C. (131° F.). The total germination of 30 per cent compared with the 40 per cent of untreated seed indicates, however, that some of the seed was injured. There is no evidence, therefore, that water treatment is of any value.

*Freezing the Seed.*—Freezing has been found beneficial in hastening the germination of some hard seeds, such as those of peaches. The effect of freezing was, therefore, tested with olive seeds. Temperatures of from —12° C. to —16° C. for various lengths of time were used. Some of the seeds were immersed in water during freezing and some were simply wet. The pits were placed in small metal-covered cans and immersed in a freezing mixture composed of two parts of broken ice and one part of fine table-salt.

TABLE VI

EFFECT OF FREEZING

(100 Redding seeds from Davis in each test; planted Feb. 19, 1915)

| No. of test | Treatment | Number sprouting | | | |
|---|---|---|---|---|---|
| | | May 1 | June 1 | July 1 | Aug. 16=total % |
| 1. | In water; —12° C. for 3 hrs. | 0 | 0 | 1 | 5 |
| 2. | Wet; —12° C. for 3 hrs. | 0 | 0 | 3 | 5 |
| 3. | In water; —12° C. to —16° C.; 1 hr. for 3 successive days | 0 | 0 | 0 | 0 |
| 4. | Wet; —12° C. to —16° C.; 1 hr. for 3 successive days | 0 | 0 | 0 | 0 |
| 5. | In water; —12° C. to —16° C.; 2 hrs. for 3 succesive days | 0 | 0 | 0 | 0 |
| 6. | Wet; —12° C. to —16° C.; 2 hrs. for 3 successive days | 0 | 0 | 0 | 0 |

No beneficial results were obtained in any case. Three successive freezings killed all the seed. One freezing to —12° C. (10.4° F.) killed most of the seed. The effect of cold on dry seeds was not tested. Cooling to —3° C. for one to forty-eight hours had no perceptible effect, but the tests were not very conclusive.

### C. MOST FAVORABLE CONDITIONS FOR GERMINATION

Successful germination depends not only on the condition of the seed when planted, but on the environmental conditions after planting. These conditions are the temperature, the moisture and the aeration, for each of which there is probably an optimum. Tests were made to

determine the most favorable conditions in each of these respects. The seeds used were Redding from Davis, practically 100 per cent viable. The pits were all clipped at the apex.

*Temperature.*—For this test the pits were planted in six-inch flower pots painted with paraffin to conserve the moisture. They were placed one-half inch deep in a medium light sandy soil. Two somewhat constant temperatures, that of the office regulated by a steam radiator, and that of an incubator regulated by a thermostat, and two variable temperatures, that of a greenhouse and that of the outside air, were tried. The results are shown in Table VII.

TABLE VII

EFFECT OF TEMPERATURE ON GERMINATION

(55 Redding seeds in each test; planted Feb. 22, 1915)

| No. of test | Temperature conditions | Number sprouting | | | | Total per cent |
|---|---|---|---|---|---|---|
| | | May 1 | June 1 | July 1 | Aug. 16 | |
| 1. | Outside, mean 55° F. | 0 | 23 | 29 | 29 | 53 |
| 2. | Office, mean 68° F. | 0 | 33 | 34 | 35 | 64 |
| 3. | Incubator, mean 77° F. | 0 | 0 | 0 | 0 | 0 |
| 4. | Greenhouse, mean 80° F. | 0 | 35 | 46 | 47 | 85 |

(It is possible that the seeds in the incubator may have become too dry.)

Omitting Test No. 3, it is plain that the higher the temperature, the more rapid the germination. The outside temperature was of course variable and that of the greenhouse still more so. In the latter case the temperature on a sunny day often exceeded 100° F. and on a cold night sometimes fell to 45° F. These variations, however, seem to have had no effect either good or bad. The failure of the seeds at 77° F. in the incubator is unexplained, but it is possible that they were allowed to become too dry at some time after starting.

*Moisture.*—The results given in Table VIII under this heading were the result of an accident, but are none the less suggestive. Four rows of seed were planted side by side in the hot-house. One row received the ordinary daily sprinkling only. Another was kept excessively wet by drip from an overhanging gutter. A third received a portion of this drip and a fourth a smaller portion. Four increasing amounts of moisture contents are, therefore, represented in the soil of the four rows. There was evidently sufficient moisture in the row receiving the smallest amount.

TABLE VIII

EFFECT OF VARYING DEGREES OF MOISTURE IN SEED BED

(55 Redding seed in each test; planted March 24, 1915)

| No. of test | Moisture conditions | Number sprouting | | | | Total per cent |
|---|---|---|---|---|---|---|
| | | May 1 | June 1 | July 1 | Aug. 1 | |
| 1. | Received drip from gutter | 0 | 17 | 23 | 28 | 51 |
| 2. | Received less drip from gutter | 0 | 32 | 36 | 36 | 65 |
| 3. | Received still less drip from gutter | 0 | 40 | 46 | 46 | 84 |
| 4. | Sprinkled once a day, no drip | 0 | 43 | 47 | 53 | 96 |

The deleterious effect of excessive watering is plainly shown by these tests. The injury in this case is probably indirect and due to the shutting off of oxygen by preventing proper aeration. It is probably of the same character as that shown in the next tests.

*Soil Texture and Depth of Planting.*—While both the physical and chemical nature of the soil will undoubtedly affect the growth of the seedling after it has started, it seems probable that the germination of the seed is independent of the chemical nature. The effect of the soil on germination depends principally on the way in which it affects the temperature, moisture and aeration. The tests shown in Table IX were made in the hot-house and the moisture received was sufficient in all cases. The differences in results were therefore due almost or entirely to differences in aeration. The heavier the soil and the deeper the planting, the more the seed was removed from the influence of the oxygen of the air.

TABLE IX

EFFECT OF SOIL TEXTURE AND DEPTH OF PLANTING

(Redding seed)

| No. of test | Nature of soil | Depth of planting | No. seed planted | Date of planting | Number sprouting | |
|---|---|---|---|---|---|---|
| | | | | | Aug. 1 | Per cent |
| 1. | 1 part sand<br>1 part compost | 1 in. | 100 | Feb. 19 | 44 | 44 |
| 2. | 2 parts sand<br>1 part compost | ½ in. | 55 | Feb. 22 | 47 | 85 |
| 3. | 4 parts sand<br>1 part compost | ⅛ in. | 55 | Mar. 24 | 53 | 96 |

This experiment indicates clearly that a light, open, well-aerated soil is most favorable to germination. It also indicates that the shallower the seed is planted the better, providing it is not allowed to become too dry.

*Grafting Stock.*—There is nothing in these experiments to indicate what is the best stock on which to graft our olives. They show, however, that Redding seedlings have many of the characteristics of a good grafting stock, and grafted trees at present bearing in many orchards show that they have others.

Many Redding trees are scattered all over the state and the variety is fruitful. This makes it easy to procure the seed in any desired quantities. The seed is small and of very high germinating power. The growing of seedlings is therefore simple. The seedlings are very uniform in size and character, making it possible to obtain grafted trees of even size and rendering it probable that their bearing qualities

Fig. 8.—Redding seedlings on right; Algerian on left. Both five months from seed.

will also be uniform. Finally, the seedlings are vigorous and readily take the graft with which they make an excellent union.

Incomplete tests have been made with other stocks, but so far none of them has shown any superiority over the Redding.

In Europe and Africa it is a common practice to plant the seed of wild olives, or to use wild olive seedlings found in the woods. A test was made with some seed collected by Professor R. E. Smith from a wild olive growing in Algeria. At first it promised to be superior to Redding in rapidity of growth. The seeds were very small and germinated very readily and the seedlings grew vigorously and quickly. Figure 8 shows the relative size of the two kinds at five months.

This inferiority of size of the Redding, however, was almost overcome at twenty months after growing six months in the nursery. The

Fig. 9.—Redding seedling to right; Algerian on left.
Both twenty months from seed.

low, spreading, bushy form of the Algerian seedling also was less suitable for nursery work than the tall upright growth of the Redding (see fig. 9).

## CONCLUSIONS

These results make it possible to recommend a simple and rapid method of raising Redding seedlings for grafting stock.

1. The fruit should be gathered when perfectly ripe and the pulp removed from the pits. This is most easily done by immersing the olives in a 3 or 4 per cent soda lye for several hours to soften the skin. After washing off the lye, the pulp can be removed by rubbing through a wire sieve of $\frac{3}{16}$-inch mesh.

2. The cleaned seed is then placed in 25 per cent brine (two pounds common salt to one gallon water), and all floating seed rejected.[2]

3. The apex or pointed end of each seed is then clipped, as described.

4. The clipped seed is planted directly in flats containing a light porous soil (sand three parts, leaf mold one part). The seed should be planted one-eighth to one-quarter inch deep and the surface of the soil covered with one-eighth of an inch of sifted moss or similar material.

5. The planted flats should then be placed in a greenhouse, cold-frame or ordinary seed-bed, and watered only enough to prevent complete drying of the layer around the seed. The warmer they are kept, the more rapidly the seed will germinate and grow.

6. The seedlings will commence to come up in four or five weeks and continue for two, three, or more months. At the end of about five months from planting they may all be transplanted to small pots, but they will be of many sizes, varying from a few inches to two or more feet (see figs. 10 and 11). It is probably best to pot them as soon as they reach four or five inches, as in figure 10. This will necessitate going over the seed-beds several times, but they will probably make larger trees for grafting in the spring than if they are set back by transplanting when large as in figure 11.

7. The potted seedlings are kept in a greenhouse, lathhouse or other protected place until the following spring. When the weather and the soil warm up, about April, they can be planted in the nursery and the following autumn and the next spring they will be ready for budding or grafting.

---

[2] Wash seed to remove salt before planting.

Fig. 10.—Seedlings potted when 4 to 5 inches high.

Fig. 11.—Seedlings potted when 1 to 2 feet high and cut back to 6 to 8 inches.

# PART II.—GRAFTING OLIVE SEEDLINGS

By FREDERIC T. BIOLETTI AND F. C. H. FLOSSFEDER

Olive seedlings are usually budded or grafted in the nursery. This seems to be the best way, though it is possible to plant the seedlings in place in the orchard and graft them one or more years later.

Buds may be put in during the autumn to unite and remain dormant until the following spring, or they may be put in during the spring as soon as the sap is flowing freely. Spring buds grow the same year, but do not make so large a growth during the season as those put in the previous autumn.

Grafting can be done in almost any month, but the best time seems to be just at the start of new growth, a little before the time for spring budding, usually about the middle of March in most localities.

Some growers bud their nursery plants in the autumn and graft during the following spring all on which the buds do not "take." This seems to be a good method, as it diminishes the number of failures. The bud is inserted four to six inches above the surface of the ground and the grafting is done at or just above the surface.

Neither budding nor grafting are very difficult if good scions are used. The graft scions or bud sticks should be as fresh as possible. If kept for even a few weeks they do not grow nearly so readily. They should have well formed buds. Twig buds can be used, but more of them fail; the ordinary shield bud in a T slit is the simplest form and seems as good as any. For grafting, a method by which the stock is not split seems to be the best. The bark or crown graft is the form usually employed. The scions should be not only fresh, but well developed and at least three-sixteenths of an inch in diameter; about one-quarter of an inch is perhaps the best size. If over three-eighths of an inch they are difficult to fit properly.

## GRAFTING EXPERIMENTS

In order to determine the best method of tying, waxing and covering nursery grafts a series of tests was made at Davis in 1915.

*Nursery Grafting.*—The stock used in these tests were well-grown Redding seedlings similar to that shown in figure 12. They were just

two years old from the planting of the seed and varied in diameter at the base from three-eights to five-eights inches.

Fig. 12.—Redding seedlings, two years old.

| | |
|---|---|
| Seed planted, | March, 1913 |
| Plant potted, | August 1913 |
| Put in nursery, | May, 1914 |
| Grafted, | March, 1915 |

The scions were taken from old Mission trees growing on the University Farm. The kind of scion and method of cutting are shown in figure 13. They were of good quality with well-formed dormant buds

**Fig. 13.—Mission scions—slightly reduced.**

and somewhat smaller than the stock, from one-eighth to four-eighths inches in diameter.

The method of grafting was that usually called bark or crown grafting and consists of inserting a scion, cut to a long single bevel, underneath the split bark of the stock, which has previously been cut

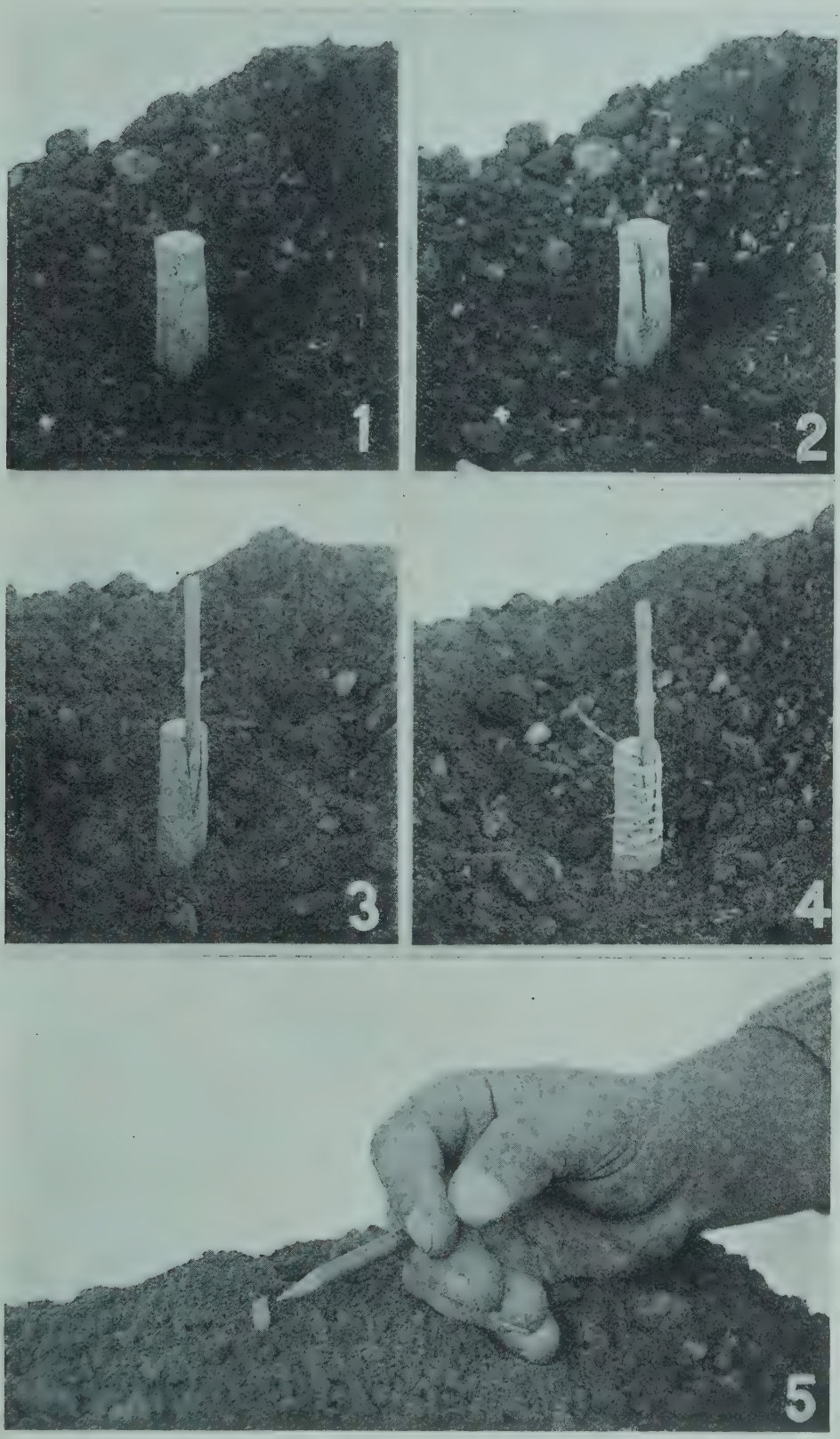



Fig. 14.—Method of grafting olive seedlings in nursery.

1. Stock decapitated. 2. Bark split. 3. Scion inserted.
4. Graft tied. 5. Graft covered with moist soil.

off an inch or so above the surface of the ground. The method is shown in figure 14. The 209 grafts made were treated in three different ways as follows:

Exp. 1. Tied with raffia, waxed, and covered with soil to just above the union.
Exp. 2. Tied with raffia, waxed and covered with soil to the top of the scion.
Exp. 3. Tied with cotton string, no wax, covered with soil to the top of the scion.

The grafting was done on March 19, and on July 1 the results were noted as follows:

| | | |
|---|---|---|
| Exp. 1. | 20 strong grafts, 6 weakly. | Good grafts, 24.7% |
| Exp. 2. | 44 strong grafts, 6 weakly. | Good grafts, 54.3% |
| Exp. 3. | 36 strong grafts, 5 weakly. | Good grafts, 76.6% |

From this it appears that for the conditions of the test the following conclusions may be drawn:

1. Deep covering of the graft with moist soil is necessary. Compare Experiments 1 and 2.

2. When the grafts are covered deeply, waxing is detrimental. Compare Experiments 2 and 3.

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# A COMPARISON OF ANNUAL CROPPING, BIENNIAL CROPPING, AND GREEN MANURES ON THE YIELD OF WHEAT

BY

B. A. MADSON

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BENJAMIN IDE WHEELER, President of the University.

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By B. A. MADSON

It has been observed that the productive power of the arid and semi-arid soil of the west is more often limited because of an insufficient supply of moisture or because of improper physical and biological conditions than because of a lack of certain fertilizing elements. This is especially true where dry farming is practiced, in which case the cereals constitute the principal crop grown. In the more humid sections, where water is usually abundant, corresponding defects in physical and biological conditions may generally be corrected by the use of systems of crop rotation. Under arid conditions the development of a comprehensive system of crop rotation is rendered somewhat difficult because of the limited number of crops adapted to these conditions. Some modification of this character, however, is necessary in the system of grain farming in California, as evidenced by the fact that wheat production in the state has decreased more than 80 per cent during the past ten years, a condition which can be attributed largely to the deleterious effects of continuous one-sided cropping.

To overcome this deficiency of crops, a year of fallow and addition of organic matter to the soil by the use of cover crops have been advocated. The year of fallow is recommended primarily as a moisture-conserving measure, to make possible an adequate supply of moisture in the soil for a maximum crop at all times. The use of the cover crop, on the other hand, is recommended as a means of maintaining the supply of humus which is lost so rapidly by oxidation under continuous cultivation and cropping. Humus appears to be necessary to keep the soil in good tilth, to stimulate bacterial activity and to maintain its maximum moisture-holding capacity. One or both of these practices, together with proper cultivation, have been found under many conditions not only to aid materially in maintaining the productivity of dry-farm soils but in many cases to be absolutely essential

* The experiment discussed in this publication was outlined by and executed under the direction of Dr. G. W. Shaw, in charge of the Agronomy work until 1913. The field work was conducted under the supervision of Mr. A. J. Gaumnitz, in charge of the experimental work at Davis during the same period of time.

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By B. A. MADSON

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To overcome this deficiency of crops, a year of fallow and addition of organic matter to the soil by the use of cover crops have been advocated. The year of fallow is recommended primarily as a moisture-conserving measure, to make possible an adequate supply of moisture in the soil for a maximum crop at all times. The use of the cover crop, on the other hand, is recommended as a means of maintaining the supply of humus which is lost so rapidly by oxidation under continuous cultivation and cropping. Humus appears to be necessary to keep the soil in good tilth, to stimulate bacterial activity and to maintain its maximum moisture-holding capacity. One or both of these practices, together with proper cultivation, have been found under many conditions not only to aid materially in maintaining the productivity of dry-farm soils but in many cases to be absolutely essential

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to successful crop production. On the sandy soils near Ceres, in the San Joaquin Valley, Shaw[1] found that by the use of the summer fallow alone the yield of wheat could be more than doubled, while by the use of green manure crops, combined with the summer fallow, the yield was increased from 230 to 340 per cent, depending upon the amount of organic matter added. Necessarily, however, the effect of these treatments will vary not only with the total precipitation and its seasonal distribution but more particularly with the type and character of the soil.

In order to secure some information as to the value of these treatments under Sacramento Valley conditions, a biennial cropping experiment was begun in 1907 on the University Farm at Davis, a portion of which was previously discussed by Shaw in the bulletin above cited. This project was designed to show the effects of fallow and of various green manure crops in combination with the fallow, as compared with continuous cropping on the yield of wheat. The results obtained in this investigation since the publication of Professor Shaw's bulletin are presented in this bulletin, with such discussions as these may suggest.

*Climate.*—The climate at Davis is usually classed as semi-arid. The normal precipitation is approximately 17.32 inches, the greater portion of which falls during the winter months, while the months of June to September are generally absolutely rainless. There is, however, a very wide variation in the seasonal precipitation, as indicated by the subjoined table. This fact and the frequent occurrence of hot north winds during the spring and summer months render moisture-conserving measures imperative.

TABLE I

RAINFALL AT DAVIS

| Seasons, | 1907–08 | 1908–09 | 1909–10 | 1910–11 | 1911–12 | 1912–13 | 1913–14 |
|---|---|---|---|---|---|---|---|
| Inches ..... | 13.16 | 22.48 | 11.35 | 23.18 | 9.41 | 8.84 | 28.70 |

*Soil.*—The soil type upon which this experiment was undertaken is technically known as Davis silt loam. The surface soil is a rather heavy silt loam varying in depth from four to five feet. It is, however, in fair physical condition, is relatively easy to work, and has a maximum water-holding capacity of approximately 30 per cent, according to field determinations. This surface soil is underlaid by a layer of sand six to eight inches in thickness and this in turn underlaid by a heavier clay loam.

[1] Calif. Bulletin No. 211, p. 267.

The project consisted of fourteen one-tenth acre plats quite uniform in character and included five trials with various green manure crops as compared with bare fallow and with continuous cropping. Each test was made in duplicate, so that of the biennial cropped plats one plat out of each series was cropped to wheat every year. During the summer of 1907 all plats were fallowed in order to disintegrate the plow sole and put the soil in as good physical condition as possible. This was deemed advisable inasmuch as the field had been cropped to grain for a number of years prior to its being used for experimental purposes.

*Treatment of Plats.*—During the subsequent year all plats received the same cultural treatment as far as conditions would permit. Plowing was done in the late fall or early winter, as soon as the rain had sufficiently moistened the ground. The surface was then worked down to a good seed bed and the wheat and the green manure crop seeded with a drill. The fallow plats were allowed to lie in the rough condition until spring, when the weed growth was destroyed and the surface worked down to an even mulch; this mulch was maintained throughout the summer by an occasional cultivation with either a harrow or a disc. On the green manure plats the cover crop was turned under in the spring, after which the surface was worked down to a mulch; this mulch was maintained throughout the summer in exactly the same manner as on the fallow plats, with one exception. Plats Nos. 38 and 39, upon which horse beans were grown as a cover crop, were plowed in the spring, worked down and planted to Kaffir corn during a part of the experiment.

When the wheat crop was removed from the plats in the summer the stubble was immediately disced, the mulch thus formed aiding materially in checking the loss of moisture from the soil by direct evaporation. The treatment of the various plats and the yields obtained are given in Table II.

In comparing the data presented in Table II it will be observed that the average yield of the two continuously cropped plats, Nos. 30 and 37, namely, 21.75 bushels per acre, is slightly higher than the average of any of the biennial cropped plats. Of the biennial cropped plats, Nos. 33 and 34, on which horse beans and fenugreek were grown as a cover crop, gave the highest returns. In all fairness, however, it must be said that the horse beans failed to produce much growth, so that their effect as a green manure crop was practically nothing. The fenugreek, however, made a fair growth, but had occasion to influence but one of the six wheat crops. In reality, therefore, the treatment of these plats prior to the use of the fenugreek was practi-

## TABLE II

TREATMENT OF PLATS FROM 1907 TO 1913 AND YIELD OF WHEAT IN BUSHELS PER ACRE

| Plat No. | Nature of treatment | 1907–08 | 1908–09 | 1909–10 | 1910–11 | 1911–12 | 1912–13 | Total 6 years' production, bu. | Average yield per acre, bu. | Grand average, bu. |
|---|---|---|---|---|---|---|---|---|---|---|
| 30 | Wheat continuously | 40.3 | 36.3 | 21.58 | 10.33 | 10.83 | 3.17 | 122.51 | 20.42 | |
| 31 | Wheat and fallow, alternate | 41.3 | Fallow | 28.00 | Fallow | 44.83 | Fallow | 114.13 | 19.02 | 20.42 |
| 32 | Fallow and wheat, alternate | Fallow | 55.60 | Fallow | 24.75 | Fallow | 43.83 | 124.69 | 20.69 | 19.85 |
| 33 | Horse beans and wheat, alternate | Horse beans | 51.60 | Horse beans | 34.83 | Fenugreek | 40.67 | 127.10 | 21.18 | 20.50 |
| 34 | Wheat and horse beans, alternate | 48.70 | Horse beans | 28.91 | Horse beans | 41.33 | Fenugreek | 118.94 | 19.82 | |
| 35 | Field peas and wheat, alternate | Field peas | 52.10 | Field peas | 34.33 | Field peas | 31.42 | 117.85 | 19.64 | 19.44 |
| 36 | Wheat and field peas, alternate | 48.50 | Field peas | 29.25 | Field peas | 37.66 | Field peas | 115.23 | 19.23 | |
| 37 | Wheat continuously | 56.10 | 37.30 | 22.41 | 11.00 | 6.66 | 5.08 | 138.55 | 23.09 | 23.09 |
| 38 | Horse beans and Kafir and wheat, alternate | Horse beans, Kafir | 41.00 | Horse beans, Kafir | 28.58 | Horse beans | 28.58 | 98.16 | 16.36 | 18.39 |
| 39 | Wheat and horse beans and Kafir, alternate | 55.00 | Horse beans, Kafir | 31.83 | Horse beans, Kafir | 45.60 | Horse beans | 122.49 | 20.41 | |
| 40 | Rye and vetch and wheat, alternate | Rye & vetch | 46.00 | Rye & vetch | 29.00 | Rye & vetch | 9.17 | 84.17 | 14.03 | 15.32 |
| 41 | Wheat and rye and vetch, alternate | 55.10 | Rye & vetch | 32.08 | Rye & vetch | 12.50 | Rye & vetch | 99.68 | 16.61 | |
| 42 | Burr clover and wheat, alternate | Burr clover | 38.60 | Burr clover | 26.16 | Burr clover | 23.67 | 88.43 | 14.74 | 18.68 |
| 43 | Wheat and burr clover, alternate | 55.90 | Burr clover | 40.41 | Burr clover | 39.50 | Burr clover | 135.81 | 22.63 | |

cally the same as on the bare fallow. On plats Nos. 38 and 39 the horse beans were likewise a failure.

Perhaps the most striking fact revealed by the data in Table II is the rapid decrease in yield of the continuously cropped plats during the progress of the experiment. In the case of the biennial cropped plats there appears to be no consistent change in productivity, with the exception of plats Nos. 40 and 41, upon which rye and vetch were employed as a cover crop. In fact, it is evident that had the experiment continued a few years longer all the biennial cropped plats, with the possible exception noted, would have surpassed in yield the continuously cropped plats.

It must also be remembered that all the plats were fallowed during the summer of 1907, prior to the beginning of the experiment, so that the condition on plats Nos. 30 and 37, for the first season at least, was identical with that of the biennially cropped plats. The results clearly indicate that the year of fallow very markedly affected the growth on the continuously cropped plats for at least two seasons. This is especially significant considering the short duration of the experiment. Furthermore, one plat out of each series of the biennial cropped plats was not cropped for the two seasons, 1906–07 and 1907–08, a condition which might tend to vitiate the results somewhat, though the effect,

TABLE III

Results of the Last Four Years of the Biennial Cropping Experiment

| Plat No. | 1909–10 | 1910–11 | 1911–12 | 1912–13 | Total 4 yr. Yield per acre, bu. | Av. annual yield per acre, bu. | Grand average, bu. |
|---|---|---|---|---|---|---|---|
| 30 Ck. | 21.58 | 10.33 | 10.83 | 3.17 | 45.91 | 11.48 | 11.48 |
| 31 | 28.00 | Fallow | 44.83 | Fallow | 72.83 | 18.21 | 17.67 |
| 32 | Fallow | 24.75 | Fallow | 43.83 | 68.58 | 17.14 | |
| 33 | Horse beans | 34.83 | Fenugreek | 40.67 | 75.50 | 18.87 | 18.21 |
| 34 | 28.91 | Horse beans | 41.33 | Fenugreek | 70.56 | 17.56 | |
| 35 | Field peas | 34.33 | Field peas | 31.42 | 65.75 | 16.44 | 16.71 |
| 36 | 29.25 | Field peas | 37.66 | Field peas | 67.98 | 16.98 | |
| 37 Ck. | 22.41 | 11.00 | 6.66 | 5.08 | 43.18 | 11.29 | 11.29 |
| 38 | Horse beans, Kafir | 28.58 | Horse beans | 28.58 | 57.16 | 14.29 | 16.83 |
| 39 | 31.83 | Horse beans, Kafir | 45.66 | Horse beans | 77.49 | 19.37 | |
| 40 | Rye & vetch | 29.00 | Rye & vetch | 9.07 | 38.17 | 9.54 | 10.34 |
| 41 | 32.08 | Rye & vetch | 12.50 | Rye & vetch | 44.58 | 11.14 | |
| 42 | Burr clover | 26.16 | Burr clover | 23.17 | 49.83 | 12.46 | 16.22 |
| 43 | 41.41 | Burr clover | 39.50 | Burr clover | 79.91 | 19.98 | |

if any, is less apparent. Again, on the green manure plats the treatment in some cases did not become effective until the third year, so that only the last four years show a true comparison of the various treatments. On the whole, therefore, it would probably be better to regard the first two seasons' results as preliminary and to include only the last four years' results in comparing the merits of the various treatments. The yields considered on this basis are given in Table III.

The results of the last four years have been decidedly in favor of biennial cropping, with the exception of plats Nos. 40 and 41, on which rye and vetch were employed as a cover crop. The difference in yield, however, between the continuously cropped plats and the biennially cropped plats is too great to be attributed to any other factor than the effect of the treatment given. Unfortunately no determinations were made on the green manure plats to ascertain whether or not there was any relation between the total weight of organic matter added to the soil and the yield produced. Attention must be called to the fact, however, that the green manure plats, Nos. 40 and 41, which gave the lowest average yield, not only for the last four years but throughout the experiment were the only ones upon which a cereal was employed as a cover crop. It is quite probable that the total organic matter added was greater when rye was used as a part of the cover crop than when a legume alone was used. This would seem to indicate either that the growth of a larger cover crop tended to reduce correspondingly the water content of the soil, thereby affecting the yield of the following crop, or that the cereal (rye) exerted some influence on the soil which affected the growth of the succeeding crop unfavorably. On the whole, in comparing the effect of the various cover crops with bare fallow the results would indicate that the cover crop was harmful rather than beneficial. However, plats Nos. 33 and 34, upon which horse beans and fenugreek were grown as cover crops, the former being almost a total failure, gave a slightly higher yield than the bare fallow plats. Even plats Nos. 38 and 39, upon which the cover crop of horse beans was followed by Kafir corn during the first four years, gave as large a yield of wheat throughout the experiment as did the field peas and bur clover plats. While the Kafir did not mature in most cases, the yield of forage varied from four to eight tons per acre, the growth of which must have caused a considerably greater draft upon the moisture supply of the soil than did the cover crops. Furthermore, the Kafir and other sorghums are generally considered to be "hard" on the soil, greatly reducing the yield of the following cereal crops.

The rapid and consistent decrease in yield of both the continuously cropped plats is striking. At first it would appear that this decrease

might be accounted for by an insufficient supply of moisture. For the last two crops at least this is doubtless true, as the rainfall was very low, the combined precipitation for the two seasons being only 18.25 inches. On the whole, however, there seems to be no close correlation between the average yield of the continuously cropped plats

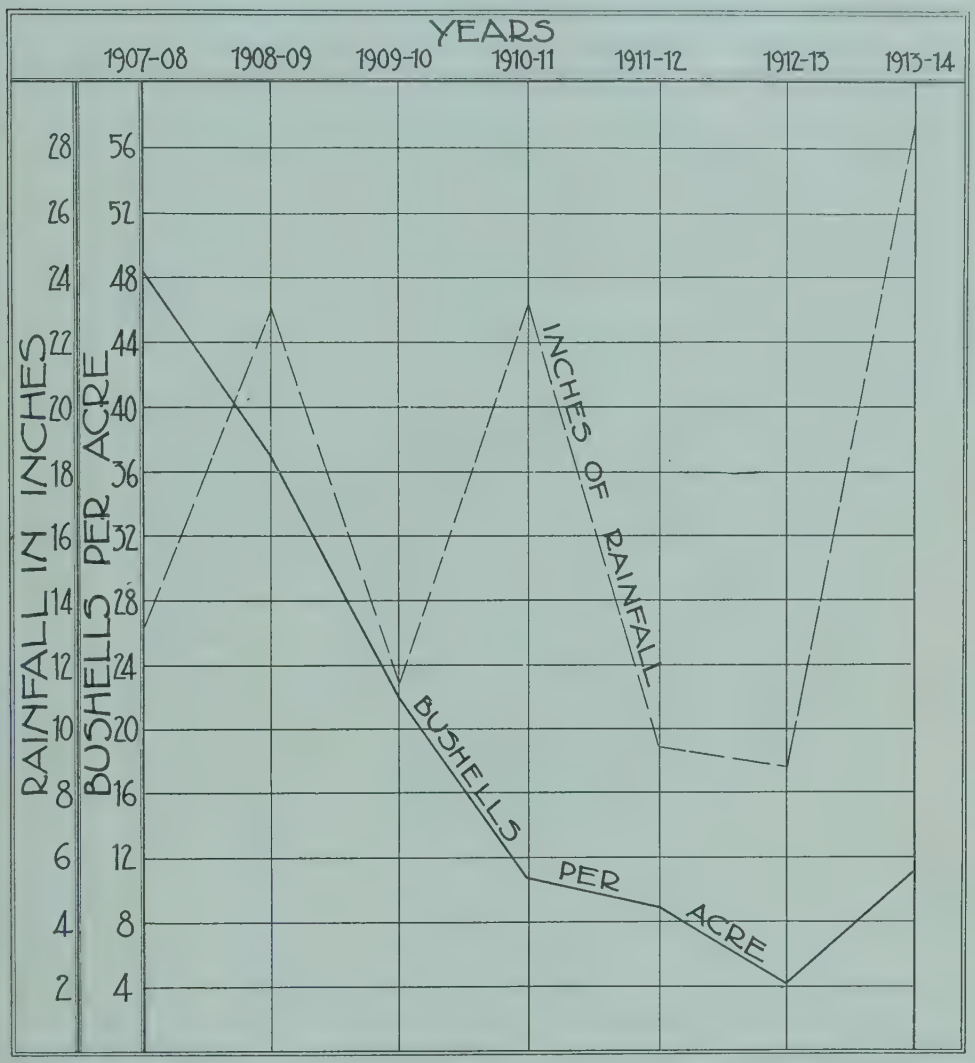


FIG. 1—CURVES SHOWING THE RELATION BETWEEN THE RAINFALL AND THE YIELDS ON THE PLATS CROPPED TO WHEAT CONTINUOUSLY

and the seasonal precipitation, as is shown by figure 1, the yield decreasing continually while the precipitation was decidedly variable. It is further worthy of note that in 1913, the second of two dry years, the yield on plat No. 32, which was fallowed the previous season, was 43.83 bushels of wheat per acre, while plat No. 33, to which a cover

crop of fenugreek had been added the previous season, yielded 40.67 bushels of wheat per acre. The results obtained the succeeding season (1914) further strengthened the belief that water alone was not the limiting factor. While the experiment was technically closed at the end of the 1913 season, all the plats, with the exception of No. 32, were cropped to some cereal the next year, the results of which are given in Table IV. Plats Nos. 30 and 31 were both planted to the same variety of wheat. It will be noted that the yield of plat No. 30, which has been cropped to wheat continuously, was only 11.17 bushels per acre in spite of the fact that the seasonal precipitation was 28.70 inches.

TABLE IV

YIELD OF CEREALS ON THE PLATS OF THE BIENNIAL CROPPING EXPERIMENT, SEASON OF 1914

| Plat No. | Treatment, 1913 | Crop grown, 1914 | Yield per acre, bu. |
|---|---|---|---|
| 30 | Wheat | Bobs Wheat | 11.17 |
| 31 | Fallow | Bobs Wheat | 25.42 |
| 32 | Wheat | Fallow | -------- |
| 33 | Wheat | Beldi Barley 190 | 58.20 |
| 34 | Fenugreek | Beldi Barley 190 | 65.20 |
| 35 | Wheat | Imp. Beldi Bar. 1601 | 53.80 |
| 36 | Field Peas | Chevalier Bar. 5865 | 65.60 |
| 37 | Wheat | Chevalier Bar. 5865 | 29.40 |
| 38 | Wheat | Chevalier Bar. 5865 | 52.80 |
| 39 | Horse Beans | Burt Oats 293 | 40.00 |
| 40 | Wheat | Burt Oats 293 | 44.69 |
| 41 | Rye and Vetch | Burt Oats 293 | 47.66 |
| 42 | Wheat | White Aust. Wh. 12113 | 28.16 |
| 43 | Burr Clover | White Aust. Wh. 12113 | 24.37 |

Plat No. 31, which had been fallowed the previous season, yielded 25.42 bushels of wheat per acre. The other plats in the experiments were cropped to various cereals, so that an exact comparison cannot be made. The results on the other continuously cropped plats and the two adjoining plats, Nos. 36 and 38, which were seeded to Chevalier barley, are also of interest. Plat No. 37, which had been continuously cropped to wheat, yielded only 39.4 bushels of barley per acre. Plat No. 38, cropped to wheat the previous season, which was preceded by a cover crop of horse beans, yielded 52.8 bushels per acre, and plat No. 36, upon which had been grown a cover crop of field peas in 1913, yielded 65.6 bushels of barley per acre. It does not seem probable that in either instance the difference in yield could be attributed to a

difference in moisture supply, as all plats were abundantly supplied with moisture throughout the growing season. In fact, the heavy spring rains kept the soil nearly saturated until the crop was fully headed.

From the data obtained it would certainly appear that some factor other than the lack of moisture was responsible for the decline in yield under continuous cropping. Considering the results obtained on the plats in which rye was used as a part of the cover crop, it would appear that the cereal exerted some unfavorable influence upon the succeeding grain crop. Whether this condition is due to some toxic substance left in the soil, to the development of fungi, as maintained by Bolley, or to some effect of the fibrous root system on the physical, chemical or biological condition of the soil is still undetermined. The results, however, would suggest that some effect of this character was the real limiting factor. The fact that most of the plats upon which a leguminous cover crop had been grown gave a lower yield than the bare fallow plats might be explained on the basis of moisture, the cover crop using a portion of the moisture which might otherwise have served to supply the wheat crop. This explanation seems plausible, since the difference in yield during seasons of high rainfall was very slight, the greatest difference occurring during the drier seasons. It would seem, therefore, that while the addition of organic matter may be of value, its beneficial effect is not sufficient to compensate for the water used in its growth, nor does the soil appear to be seriously lacking in any constituent which the cover crop might add.

From an economic point of view, the bare fallow unquestionably produced the greatest net returns per acre. The cost of maintaining a good summer fallow, including plowing and the necessary cultivation, is usually slightly less than the cost of producing a crop of wheat. The annual increase in yield of 6.29 bushels per acre, which was obtained from the fallow plats, is therefore largely clear gain. In other words, to be economically a success, the fallow plats would have to produce only twice as large yields every alternate year as was produced by the continuous cropped plats annually, whereas the actual average production of the fallow plats every two years was 35.35 bushels per acre, as compared with 11.38 bushels per acre, which was the annual production of the plats cropped continuously.

In the case of the green manure plats, while the yields were considerably larger than those obtained under continuous cropping, they were, on the whole, somewhat lower than the yield obtained on the fallow plats. Furthermore, the cost of producing and handling the green manure crop is at least 50 per cent greater than the cost of

maintaining the fallow, including as it does the cost of putting in the crops, the cost of the seed and additional plowing in the spring, besides the same summer cultivation that is given to the fallow. On the whole, therefore, the actual economic returns attending the use of a green manure crop is but slightly greater than those obtained under a system of continuous cropping.

## EFFECTS ON THE SOIL

It is usually maintained that the addition of organic matter to the soil by the use of green manure crops will aid in increasing its humus content. In humid sections this is true, and experiments have shown that the plowing in of a cover crop has increased the humus content in some cases 1 per cent. Under arid conditions, however, the increase in humus content by the use of a cover crop has been found in most instances to be very slight. As has been pointed out by Scofield, under arid conditions the low moisture content of the surface soil, together with high temperature and high degree of aeration, tends to stimulate direct oxidation, rather than humification, so that in a short time the larger proportion of the organic matter may be lost without adding materially to the humus content of the soil. Hilgard also states that "in the absence of a sufficient degree of moisture to cooperate with the agencies of humification the final results in the soil is practically the same as in the 'fire fanging' of dung. The organic matter is almost wholly destroyed by direct oxidation with or without the aid of minute organisms, leaving essentially only the ash behind to be reincorporated with the soil."

Unfortunately no systematic studies were made to determine the effect of the various treatments upon the soil in the experiments at Davis. A few tests were made in the spring of 1913 by Mr. S. E. Goodall, at that time a senior student in the department of agriculture, with a view to determining the effect of the various treatments on the humus content of the soil, as well as on the nitrogen content of the humus. The results thus obtained are given in Table V.

The soil samples upon which these determinations were made were taken in January, about ten months after the last cover crop had been plowed in. The results indicate that no increase in humus content occurred following the application of the green manure crop. While a variation of .28 per cent of humus was obtained in the first foot, both extremes occurred on plats to which the last cover crop had been added nearly two years previous. The difference in the average humus content for the various treatments is too slight to be significant. The fact that the humus content of the first foot is slightly less on the

TABLE V

HUMUS AND HUMUS NITROGEN CONTENT OF SOILS, JANUARY, 1913

| Plat No. | Per cent of Humus | | | Per cent Nitrogen in Humus | | |
|---|---|---|---|---|---|---|
| | 1st ft. | 2nd ft. | 3rd ft. | 1st ft. | 2nd ft. | 3rd ft. |
| 30 | 1.12 | .86 | .62 | 15.0 | 11.2 | 19.4 |
| 31 | 1.02 | .90 | .54 | 8.5 | 8.5 | 13.5 |
| 32 | .98 | .90 | .54 | 10.6 | 10.6 | 14.7 |
| 33 | 1.10 | .90 | .54 | 9.5 | 7.5 | 10.4 |
| 34 | .94 | .82 | .52 | 8.5 | 9.8 | 10.4 |
| 35 | 1.06 | .88 | .72 | 9.4 | 11.2 | 12.2 |
| 36 | .94 | .80 | .60 | 10.1 | 9.8 | 10.7 |
| 37 | 1.06 | .80 | .64 | 8.0 | 9.9 | 11.7 |
| 38 | 1.14 | .94 | .70 | 10.3 | 10.8 | 13.4 |
| 39 | 1.18 | 1.02 | .62 | 9.9 | 10.5 | 16.4 |
| 40 | 1.18 | .90 | .62 | 10.2 | 8.9 | 9.6 |
| 41 | 1.10 | .96 | .66 | 9.5 | 7.3 | 10.1 |
| 42 | 1.14 | .70 | .54 | 8.8 | 10.0 | 12.2 |
| 43 | 1.22 | .74 | .56 | 8.4 | 8.9 | 8.6 |
| Av. of continuously cropped plats, | 1.09 | .83 | .63 | 11.5 | 10.5 | 15.5 |
| Av. of fallow plats, | 1.00 | .90 | .54 | 9.5 | 9.5 | 14.1 |
| Av. of green manure plats, | 1.10 | .86 | .61 | 9.4 | 9.5 | 11.4 |

fallow plats than on the other plats corroborates the usual observations as to the effect of summer cultivation on the oxidation of the humus.

In the nitrogen content of the humus, it is not clear just why the humus in the soil of the continuously cropped plats should be higher in nitrogen than that of the other plats. The most probable explanation would be that less of the organic matter left in the soil as wheat roots was lost by direct oxidation than in the case of that applied as cover crops. In the latter case, in the process of oxidation it is quite likely that a large portion of the nitrogen was lost as well. Another possibility that suggests itself is that a more rapid rate of nitrification occurred when the green material had been added than on land that had been cropped, so that a larger portion of the nitrogen was changed to the nitrate form. In the absence of nitrate determinations, however, this can only be assumed.

From the results obtained in this experiment it would appear that soils such as those at Davis contain sufficient organic matter to meet the demands of a normal crop. While the addition of organic matter by the use of a cover crop may tend to stimulate bacterial activity and the liberation of plant food, the benefit thus derived is not sufficient to counterbalance the draught made upon the soil moisture by the growth of the crop. Furthermore, because of the rapid oxidation

which takes place in the soil the cover crops did not increase the humus content, but were entirely lost before the next wheat crop was grown.

On the other hand, the bare fallow greatly stimulated the crop-producing power of the soil, though it is evident that if long continued the humus content will be seriously depleted. It will doubtless, therefore, eventually be necessary to add organic matter in some form if the crop-producing power of these soils is to be permanently maintained. It would also appear that there was considerable difference in the comparative value of the various crops for green manure purposes, though the exact reason for this is not clear.

Again, while the highest economic returns were obtained from the bare fallow, it does not hold that biennial cropping as practiced in this experiment is necessarily productive of the greatest returns. It is quite likely that from an economic point of view the use of the fallow every third or even every fourth year would give larger total returns over a long period of time than biennial cropping. As an integral part of a dry-farm rotation, however, its value can not be questioned.

## CONCLUSIONS

1. The marked decline in wheat production in California has been caused by the deleterious effects of continuous one-sided cropping, together with inadequate cultivation.

2. Under a system of continuous cropping to wheat the yield decreases very rapidly to a point below profitable production.

3. The year of fallow is one of the most effective means of retaining the productive power of semi-arid soils.

4. The use of green manure crops increases the productivity of the soil, but not to the same extent as does the bare fallow.

5. There appears to be a decided difference in the effect of the various cover crops. Apparently a cereal should not be used as a cover crop in a cereal rotation on soils such as those on the University Farm at Davis.

6. The organic matter added to the soil by the cover crop appears to be practically lost by oxidation the following summer.

7. The frequent use of the fallow will probably hasten the depletion of the humus content of the soil, even though it greatly increases its productive power.

8. The use of cover crops, even if they be legumes, does not seem to increase the content of humus or of humus nitrogen in the soil to any appreciable extent; the favorable effects of cover crops that are frequently observed must, therefore, be attributed to other causes than an increase of the humus in the soil.

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# Commercial Fertilizers

By P. L. HIBBARD

BULLETIN No. 272

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BENJAMIN IDE WHEELER, President of the University.

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# COMMERCIAL FERTILIZERS.

By P. L. Hibbard.

This bulletin comprises the results of the fertilizer inspection work of the California Fertilizer Control for the fiscal year ending June 30, 1916.

## Purpose and Functions of the Fertilizer Control.

The duty of the Fertilizer Control is:

*First:* To issue certificates of registration to manufacturers and dealers who have complied with the law by filing a sworn statement of composition and sources of the fertilizers they wish to sell.

*Second:* To analyze these fertilizers as found in the open market and publish the results for the information of the public. If a manufacturer sells fertilizers which are materially below his guarantee in composition or value he is subject to prosecution and fine. By this means it is intended to insure to purchasers that the fertilizers they buy shall be substantially as good as represented.

By a study of the reports of analyses of fertilizers, the consumer should be able to determine whether the materials he buys are sold for a fair price, and whether he obtains fertilizers of the desired composition. In short, the function of the Fertilizer Control is to see that the manufacturer gives the consumer a square deal.

## Maintenance of Guarantees.

Every manufacturer is required by law to guarantee the percentage of nitrogen, phosphoric acid and potash in the fertilizers he sells. Owing to difficulties of sampling and analysis the law permits a maximum deficiency of 0.25% nitrogen, 1.00% phosphoric acid, 0.50% potash from the figures guaranteed. Greater deficiencies than these are regarded as infractions of the law, for which the manufacturer may be prosecuted and fined. Such deficiencies are indicated in the report of analyses in black face type.

Some manufacturers uphold their guarantees better than others. The following table is a condensed report of the deficiencies found in the main table of analyses. It summarizes the work done in this laboratory on each manufacturer's goods. The columns headed Deficiencies—per cent of possible, may be used for comparison of the various companies as to probability of meeting their guarantees. The other columns are necessary to show how these figures were obtained. In cases where very few analyses are reported for a manufacturer, the figures should be taken with caution, as perhaps not properly representative. When several samples of one manufacturer's goods were

analyzed the figures may be accepted as probably a fair indication of the reliability of his guarantee.

In general, manufacturers have more than maintained their guarantees, so that an average of all the analyses would show a substantial increase over the amount guaranteed.

This table is a condensed statement of the performances of each company during the fiscal year 1915-16, and as such may be an indication of what may be expected in the future. A manufacturer who maintained his guarantees well last year will probably do the same this year.

**Maintenance of Guarantees by Manufacturers.**

| Manufacturer | Number of brands sampled | Number of samples analyzed | Total number of guarantees on samples analyzed | Deficiencies | | | |
|---|---|---|---|---|---|---|---|
| | | | | In guarantees | | In valuation | |
| | | | | Number | Per cent of possible | Number | Per cent of possible |
| Agricultural Chemical Works | 21 | 58 | 151 | 9 | 6.0 | 3 | 5.3 |
| American Agricultural Chemical Co. | 6 | 24 | 72 | 0 | 0.0 | 0 | 0.0 |
| Armour Fertilizer Works | 28 | 139 | 294 | 15 | 5.1 | 9 | 6.6 |
| Rogers Brown & Co. | 2 | 3 | 6 | 2 | ------ | ------ | ------ |
| California Fertilizer Works | 3 | 5 | 12 | 1 | 8.3 | 0 | 0.0 |
| Cudahy Packing Co. | 9 | 14 | 19 | 4 | 21.1 | 1 | 11.1 |
| Diamond Fertilizer Co. | 1 | 9 | 18 | 0 | 0.0 | ------ | ------ |
| Duff's Fertilizer Co. | 3 | 3 | 3 | 0 | 0.0 | 1 | ------ |
| General Fertilizer Association | 12 | 19 | 52 | 13 | 25.0 | 5 | 31.2 |
| Germain Seed and Plant Co. | 1 | 2 | 4 | 0 | 0.0 | 0 | 0.0 |
| Globe Grain and Milling Co. | 1 | 1 | 3 | 0 | 0.0 | ------ | ------ |
| Hauser Packing Co. | 6 | 30 | 56 | 3 | 5.4 | 1 | 3.8 |
| Hawaiian Fertilizer Co., Ltd. | 10 | 10 | 23 | 0 | 0.0 | 0 | 0.0 |
| Los Angeles Fertilizer Co. | 2 | 2 | 5 | 1 | 20.0 | 0 | 0.0 |
| Mountain Copper Co. | 2 | 3 | 5 | 0 | 0.0 | 0 | 0.0 |
| Nitrate Agencies Co. | 1 | 2 | 2 | 0 | 0.0 | 0 | 0.0 |
| Oakland Meat and Packing Co. | 1 | 2 | 2 | 0 | 0.0 | 0 | 0.0 |
| Pacific Bone, Coal and Fertilizing Co. | 7 | 17 | 29 | 2 | 6.9 | 1 | 6.6 |
| Pacific Coast Beef and Provision Co. | 1 | 1 | 2 | 0 | 0.0 | 0 | 0.0 |
| Pacific Guano and Fertilizer Co. | 11 | 21 | 45 | 2 | 4.4 | 1 | 4.8 |
| Pacific Reduction Co. | 1 | 7 | 21 | 1 | 4.8 | ------ | ------ |
| Redlands Fruit Association | 1 | 1 | 1 | 0 | 0.0 | 0 | 0.0 |
| Swift & Co. | 1 | 1 | 2 | 0 | 0.0 | 0 | 0.0 |
| Union Fertilizer Co. | 3 | 13 | 37 | 0 | 0.0 | 0 | 0.0 |
| Union Superphosphate Co. | 1 | 1 | 1 | 0 | 0.0 | 0 | 0.0 |
| Western Fertilizer Co. | 1 | 3 | 9 | 5 | ------ | ------ | ------ |
| Western Meat Co. | 16 | 76 | 153 | 17 | 11.1 | 7 | 9.3 |

Owing to the possibility of misunderstanding, the figures for percentage deficiencies are not given in above table in cases where less than 4 samples were analyzed.

Fertilizers sold on Station analysis, and some others, are not given a valuation in the table of analyses, hence the number of such samples is deducted from the total number analyzed, in computing deficiencies in valuation.

## Mechanical Condition of Fertilizers.

A good degree of fineness is one of the essential qualities of a good fertilizer. It may be assumed as generally true that the finer the material the higher the availability, hence the consumer should insist on having finely ground fertilizers. Unfortunately some manufacturers are at times careless in regard to the fineness of their goods. The insistent demand of the consumer is the most effective means of correcting such carelessness.

Besides the low agricultural availability and the difficulty in applying coarse fertilizers, it is almost impossible to obtain a satisfactorily representative sample of such goods for analysis. This is a prolific source of dissatisfaction and disagreement between buyers and sellers. During handling and transportation a coarsely ground tankage will separate so that the top of the sack contains the coarser material, high in nitrogen, while the bottom contains the finer parts of bone, high in phosphoric acid. A mixture of coarse bone meal with sulfate of potash will separate into coarse bone at the top and excess of potash at the bottom.

One of the chief reasons for the existence of the fertilizer manufacturer is that he is better prepared than the farmer to grind and mix the goods he sells, and the farmer should insist that he do it well.

## Caution in Regard to Labeling Fertilizer Packages.

The law expressly states that every package of fertilizer shall be accompanied by a plainly printed label giving the brand name, analysis, and source of the materials in the package. This requirement is not satisfactorily met by some manufacturers and dealers. Farmers are hereby cautioned that if they buy improperly or inadequately labeled fertilizers or goods not sold by properly registered dealers or their authorized agents they may lose the protection afforded by the Fertilizer Control. Consumers should insist that fertilizer tags show plainly both the percentage and the derivation of each ingredient. A verbal statement given by the selling agent should not be accepted as adequate. The honest manufacturer is willing to guarantee his goods properly, and the farmer will best serve his own interest by dealing with no other.

## Proper Basis for Buying Fertilizers.

For the purpose of this discussion, a fertilizer is a material furnishing plant food, specifically, nitrogen, phosphoric acid or potash. Lime, gypsum, humus, etc., are often of great use in improving crops, but they are not to be regarded as fertilizers in the sense here meant.

Now, if the farmer will realize that in buying fertilizers he is really buying nitrogen, phosphoric acid, or potash, nothing else, he will have

the only solid basis on which to calculate the commercial value of the goods purchased. He should pay only the fair market price for value received. Consequently the price should depend entirely on the amount of plant food. The amount of plant food can be found in only one way, by chemical analysis. Therefore, the price should depend on the result of chemical analysis. In the language of dealers, this is known as buying on the *unit basis*. A dealer buys 100 tons of tankage guaranteed to contain 8 per cent of nitrogen and 8 per cent of phosphoric acid, at a price of $3.40 per unit for the nitrogen and 90 cents per unit for the phosphoric acid. This makes it cost $34.40 per ton. But if the analysis shows 7 per cent nitrogen and 10 per cent phosphoric acid, on the same basis, the cost would be $32.80 per ton. In other words, the dealer pays for just what he gets in plant food, and for nothing else. The farmer should buy on the same basis. In buying on the unit basis the farmer should escape the high price of plant food usually paid for it when buying low-priced fertilizers by the ton. The farmer should avoid the dealer who is not willing to sell on the unit basis.

## Deficiencies.

In the analyses of the above samples, the following number of deficiencies greater than allowed by law occurred:

| | |
|---|---|
| Available phosphoric acid (total when available is not guaranteed) | 21 |
| Total nitrogen | 46 |
| Potash | 8 |
| In valuation | 33 |

These deficiencies were found in 63 samples.

The fertilizer law allows a deficiency of 0.25 per cent in nitrogen, 0.50 per cent in potash, and 1 per cent in available phosphoric acid.

## Fertilizer Valuations.

The calculations of the commercial values of the fertilizers here reported are made on the so-called unit basis. Such calculations consist simply in multiplying the number of per cent of each ingredient by the price per unit and adding the products. The sum thus obtained is the commercial value per ton at the prices used. If it is desired to use such a calculation for determining the amount which should be paid for goods, or the rebate to which the buyer is entitled owing to the goods delivered being below the guaranty, it can only be satisfactorily done if a definite price per unit has been agreed upon between buyer and seller. But for the mere purpose of showing the relative values of goods to guaranties, it is not at all necessary that the prices adopted should be the exact market prices. Thus it is that the Fertilizer Control in attempting to show the relation between values found

and values claimed, uses a schedule which is admittedly only an approximate average of market values. Owing to market fluctuations, differences in cost of delivery at different points, and other causes, the obtaining of true average market prices is an impossibility. But if the reader will bear in mind the true purpose of the valuations reported, these will have served their turn and he will not be led to assume that the Experiment Station is dictating the prices at which goods shall be sold. Valuations thus construed should serve two purposes.

(*a*) To show whether a certain fertilizer is commercially worth its cost.

(*b*) As a measure for comparing the commercial values of different brands, thus enabling the buyer to select that brand which will give him the greatest value for the money he spends.

**Schedule of Trade Values, 1916–17.**

| | Pound. | Unit. |
|---|---|---|
| Nitrogen from blood | $0.23 | $4 60 |
| Nitrogen from tankage and bone | .22 | 4 40 |
| Nitrogen from sulfate of ammonia | .19 | 3 80 |
| Nitrogen from nitrate of soda | .19 | 3 80 |
| Nitrogen from nitrate of lime | ---- | ---- |
| Nitrogen from cyanamid | .16 | 3 20 |
| Nitrogen from cottonseed meal | .22 | 4 40 |
| Phosphoric acid from bone super | .05 | 1 00 |
| Available phosphoric acid from rock super | .047 | 94 |
| Total phosphoric acid from Thomas phosphate | ---- | ---- |
| Total phosphoric acid from bone meal | .045 | 90 |
| Total phosphoric acid from tankage | .035 | 70 |
| Potash from sulfate | .05 | 1 00 |
| Potash from muriate | .05 | 1 00 |

These prices are intended to represent approximate *wholesale* cost of unmixed fertilizer materials at California freight terminals. Besides this, *retail* prices must include cost of mixing, transportation, storage, selling, long credits, bad debts, etc.

Present market quotations of high-grade potash salts are much above those here given; but as these materials are now practically not obtainable for fertilizer purposes, it seems advisable to use about the same figure that prevailed before the present disturbance began, for calculating the value of the small amounts of potash in mixed goods.

## Scope of Inspection.

During the year 507 samples of fertilizers and fertilizing materials have been received at this laboratory. Of this number 25 were sent by farmers under the two-dollar fee provision, 174 were taken by inspectors from purchasers' goods upon the request of the purchasers, and 283 were taken by inspectors from goods in the hands of agents

and manufacturers. On 17 samples the analysis as reported was used as a basis of settlement by mutual agreement of buyer and seller.* No guaranty was required or given with goods sold under such agreement. Twenty-five samples of a miscellaneous nature are omitted from the tables.

The following classification may be made of samples reported in this bulletin:

| | |
|---|---|
| Bat guano | 4 |
| Blood | 56 |
| Bone meal | 49 |
| Complete fertilizer | 195 |
| Cottonseed meal | 1 |
| Cyanamid | 2 |
| Garbage tankage | 22 |
| Nitrate of soda | 12 |
| Nitrate of soda and bone | 1 |
| Rock phosphate | 1 |
| Rape seed meal | 1 |
| Superphosphate | 8 |
| Tankage | 115 |

## Registered Manufacturers and Dealers.

The following manufacturers and dealers in commercial fertilizers have obtained certificates of registration under the provisions of the California fertilizer law, for the fiscal year beginning July 1, 1915. A list is also given of the brands of fertilizers and fertilizer materials offered for sale by them. According to the sworn returns of dealers registered for the fiscal year ending June 30, 1915, their entire sales in the state amounted to 31,540 tons. Incomplete returns for the year ending June 30, 1916, indicate approximately 29,000 tons.

No dealer or manufacturer, except those who have certificates of registration from the University of California, and their authorized agents, can legally sell fertilizers in this state. No person or company has any right to use any registration number except in connection with the firm name to which the registration certificate of such number has been issued; and no person or company to whom a registration number has been assigned has any right to give any other person or company permission to use said registration number, and any number so used is a fraud. No agent has any right to use his principal's registration number in connection with his own name.

The total number of brands registered by manufacturers was 363, of which 152 brands, equal to 42 per cent of the total, were found by inspectors and analyzed.

*Besides these a considerable number of the remaining purchasers' analyses were doubtless used subsequently as a basis of settlement, but without being reported to this office.

### Agricultural Chemical Works, Los Angeles, Cal.

REGISTRATION No. 8.

Bat Guano
Blood
Bone Meal
Brands A, B, C, F, G, H, K, L, M, N, O
Cottonseed Meal
Fish Guano
Grape and Berry
Gypsum
Lawn and Rose
Muriate of Potash
Nitrate of Soda
Nursery
Potato and Apricot
Prune and Peach
Sulfate of Ammonia
Sulphate of Potash
Summer A
Superphosphate
Tankage
Vegetable
Walnut and Almond
Special mixtures to order of consumers.

### American Agricultural Chemical Co., California Works, Los Angeles, Cal.

REGISTRATION No. 1.

Acid Phosphate
Blood.
Bradley's California Vegetable
Bradley's Hay and Grain No. 1
Bradley's Hay and Grain No. 2
Bradley's Lawn
Bradley's Lemon Tree
Bradley's Nursery Stock
Bradley's Orange and Lemon
Bradley's Special Nursery Stock
Bradley's Tree and Vine
Bradley's Nitrate of Soda
Raw Mineral Phosphate Rock
Sulfate of Ammonia
Sulfate of Potash
Tankage
Special brands to order.

### Armour Fertilizer Works, Los Angeles, Cal.

REGISTRATION No. 7.

Alfalfa Special
Armour's A, B, and C
Bean Grower
Blood
Bone Blood and Potash
Bone Meal
Cotton Seed Meal
Cropmaker
Deciduous Tree Special
Flower and Fern
Fruit and Vine
Fruit Special
Guano
Lawn and Garden
Lawn Special
Nitrate of Soda
Olive Special
Orange Tree Manure
Orange Tree Special
Sheep Manure
Special 2-12-8
Special 2-17-10
Special 2-20-3
Special 3-20-3
Superphosphate
Sulfate of Ammonia
Sulfate of Potash
Tankage
Vegetable Grower
Walnut Special
Special brands to order of consumers..

### Rogers Brown & Co., Los Angeles, Cal.

REGISTRATION No. 85.

Fish Meal
Fish Scrap
Salmon Scrap
Whale Bone Meal
Whale Meat and Blood
Whale Meat and Bone

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| Rape seed meal | 1 |
| Superphosphate | 8 |
| Tankage | 115 |

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*Besides these a considerable number of the remaining purchasers' analyses were doubtless used subsequently as a basis of settlement, but without being reported to this office.

### Agricultural Chemical Works, Los Angeles, Cal.

REGISTRATION No. 8.

Bat Guano
Blood
Bone Meal
Brands A, B, C, F, G, H, K, L, M, N, O
Cottonseed Meal
Fish Guano
Grape and Berry
Gypsum
Lawn and Rose
Muriate of Potash
Nitrate of Soda
Nursery
Potato and Apricot
Prune and Peach
Sulfate of Ammonia
Sulphate of Potash
Summer A
Superphosphate
Tankage
Vegetable
Walnut and Almond
Special mixtures to order of consumers.

### American Agricultural Chemical Co., California Works, Los Angeles, Cal.

REGISTRATION No. 1.

Acid Phosphate
Blood.
Bradley's California Vegetable
Bradley's Hay and Grain No. 1
Bradley's Hay and Grain No. 2
Bradley's Lawn
Bradley's Lemon Tree
Bradley's Nursery Stock
Bradley's Orange and Lemon
Bradley's Special Nursery Stock
Bradley's Tree and Vine
Bradley's Nitrate of Soda
Raw Mineral Phosphate Rock
Sulfate of Ammonia
Sulfate of Potash
Tankage
Special brands to order.

### Armour Fertilizer Works, Los Angeles, Cal.

REGISTRATION No. 7.

Alfalfa Special
Armour's A, B, and C
Bean Grower
Blood
Bone Blood and Potash
Bone Meal
Cotton Seed Meal
Cropmaker
Deciduous Tree Special
Flower and Fern
Fruit and Vine
Fruit Special
Guano
Lawn and Garden
Lawn Special
Nitrate of Soda
Olive Special
Orange Tree Manure
Orange Tree Special
Sheep Manure
Special 2-12-8
Special 2-17-10
Special 2-20-3
Special 3-20-3
Superphosphate
Sulfate of Ammonia
Sulfate of Potash
Tankage
Vegetable Grower
Walnut Special
Special brands to order of consumers..

### Rogers Brown & Co., Los Angeles, Cal.

REGISTRATION No. 85.

Fish Meal
Fish Scrap
Salmon Scrap
Whale Bone Meal
Whale Meat and Blood
Whale Meat and Bone

### California Fertilizer Works, San Francisco, Cal.

REGISTRATION No. 3.

Bone, Blood Meal
Bone, Blood Superphosphate
Special Fall Fertilizer
Special Fruit and Vine
Special High Grade
Special Nitrogen Fertilizer
Special Nursery Stock
Special Orange and Lemon
Special Orange Tree
Special mixtures to order of consumers.

### Citrus Fertilizer Co., Los Angeles, Cal.

REGISTRATION No. 87.

Blood
Bone Meal
Doty's Fruiting
Doty's Nursery
Doty's Special No. 1
Fish
Guano
Nitrate of Soda
Potash
Sulfate of Ammonia
Superphosphate
Tankage
Special brands to order

### Cudahy Packing Co., Los Angeles, Cal.

REGISTRATION No. 79.

A and M Fish Meal
A and M Fish Meal No. 2
Cudahy's Blood
Cudahy's Bone Meal
Cudahy's Fish Formula
Cudahy's Fish Meal No. 2
Cudahy's High Grade Tankage
Cudahy's Low Grade Tankage
Cudahy's Lawn Fertilizer
Cudahy's Lawn Special
Cudahy's Sheep Manure
Cudahy's Tankage Formula
Cudahy's Tankage No. 1
Cudahy's Tankage No. 2

### Diamond Fertilizer Co., Los Angeles, Cal.

REGISTRATION No. 77.

Barley Straw Baled
Bat Guano
Bean Straw Baled
Blood
Bone
Cotton Seed Meal
Diamond Flower and Fern Food
Diamond Lawn and Garden Fertilizer
Fish Meal
Fish Tankage
Garbage Tankage
Gypsum
Lime
Limestone Rock (ground)
Manure, Goat
Manure, Sheep
Nitrate of Lime
Nitrate of Soda
Phosphate Rock (ground)
Sulfate of Potash
Superphosphate
Tankage
Whale Blood
Whale Bone
Special mixtures to order

### Duff's Odorless Fertilizer Co., Glendale, Cal.

REGISTRATION No. 58.

Blood
Bone Meal
Duff's Lawn and Garden No. 1
Duff's Lawn and Garden No. 3
Fish Meal
Nitrate of Soda
Superphosphate
Tankage

### General Fertilizer Association, San Bernardino, Cal.

REGISTRATION No. 42.

G. F. A. Special
G. F. A. Special No. 2
G. F. A. Special No. 3
G. F. A. Special No. 4
G. F. A. Special No. 5
G. F. A. Special No. 6
Orange and Lemon No. 1
Special mixtures to order of consumers

### Germain Seed and Plant Co., Los Angeles, Cal.

REGISTRATION No. 76.

Nuvida Blood and Bone
Nuvida Flower and Fern
Nuvida Lawn and Garden Fertilizer
Nuvida Vegetable Fertilizer

### Globe Grain and Milling Co., Los Angeles, Cal.

REGISTRATION No. 83.

Samples of Variable Composition

### Hauser Packing Co., Los Angeles, Cal.

REGISTRATION No. 33.

High Grade Blood
High Grade Tankage
Low Grade Tankage
Nitrate of Soda
Steam Bone Meal
Sulfate of Potash
Special mixtures to order of consumers

### Hawaiian Fertilizer Co., Ltd., San Francisco, Cal.

REGISTRATION No. 19.

Bone Meal
Double Manure Salts
Dry Ground Blood
Fish Guano
Fruit and Vine
Grain A
Grain B
Kainit
Lawn
Lime Nitrogen
Muriate of Potash
Nitrate of Lime
Nitrate of Soda
Nursery
Orange and Lemon
Rape Seed Meal
Sulfate of Ammonia
Sulfate of Potash
Superphosphate
Tankage
Thomas Phosphate Powder
Vegetable
Whale Guano

### Thomas Lewis, Sacramento, Cal.

REGISTRATION No. 40.

Tom Lewis Bone Meal
Tom Lewis Fertilizer No. 2
Tom Lewis Star Brand Fertilizer

### Los Angeles Fertilizer Co., Los Angeles, Cal.

REGISTRATION No. 38.

Three Queens Animal Bone and Potash
Three Queens Emerson's Olive Special
Three Queens Emerson's Fall Special
Three Queens Emerson's Summer Special
Three Queens Emerson's Vegetable
Three Queens Emerson's Walnut Special
Three Queens Fruit Grower
Three Queens Fruitmore
Three Queens Garden and Lawn
Three Queens L. A. Bone Meal
Three Queens Nitrate of Soda
Three Queens Odorless
Three Queens Orangeaid
Three Queens Special Fruit Grower
Three Queens Superphosphate
Three Queens Sulfate of Potash
Three Queens T and B
Three Queens Tankage
Special mixtures to order of consumers

**Leo T. Mizuo, Los Angeles, Cal.**

REGISTRATION No. 82.

Bird Guano
Whale Bone

**Mountain Copper Co., San Francisco, Cal.**

REGISTRATION No. 28.

Mococo Superphosphate 0-17-0
Mococo 0-14-9
Mococo 3-10-2
Mococo 3-10-5
Mococo 4-10-4
Mococo 4.1-10-1.5
Nitrate of Soda
Sulfate of Potash
Special mixtures to order of consumers

**Nitrate Agencies Co., Los Angeles, Cal.**

REGISTRATION No. 45.

Nitrate of Soda
Potash
Superphosphate

**Oakland Meat and Packing Co., Emeryville, Cal.**

REGISTRATION No. 24.

"Special"

**Pacific Bone, Coal and Fertilizing Co., San Francisco, Cal.**

REGISTRATION No. 14.

Arborette No. 1
Arborette No. 2
Blood
Bone Meal
Ceres Brand
Citrona Brand No. 1
Citrona Brand No. 2
Citrona Brand No. 3
Citrona Brand No. 4
Flora Brand
Lime Nitrogen
Lucerna
Lupine Brand
Nitrate of Soda
Pomona Brand
Pomona Brand No. 2
Potash Salts
Steamed Bone and Sulfate of Ammonia
Superphosphate
Tankage
Special Formulas

**Pacific Coast Beef and Provision Co., Los Angeles, Cal.**

REGISTRATION No. 64.

Bone Meal
Dried Blood
Tankage

**Pacific Guano and Fertilizer Co., San Francisco, Cal.**

REGISTRATION No. 4.

Brand AJX
Brand CJB
Brand F&V
Brand GG
Brand HOP
Brand IXL
Brand N
Brand OK
Brand PNK
Brand PP
Brand S
Brand TRK
Brand VGR
Brand XLT
Chapman Fall Application
Chapman Fall Application Special
Chapman Spring Application
Superphosphate Cresco
Superphosphate Pacific
Special mixtures to order of consumers

**Pacific Reduction Co., Los Angeles, Cal.**

REGISTRATION No. 86.

Organic Tankage

### Redlands Fruit Association, Redlands, Cal.

REGISTRATION No. 34.

Blood
Blood, Packing House
Bone
Bone, Packing House
Nitrate of Lime
Nitrate of Soda
Salmon Scrap
Sulfate of Potash
Superphosphate
Tankage

### Rialto Orange Co., Rialto, Cal.

REGISTRATION No. 84.

Citrus No. 1
Citrus No. 2

### San Antonio Meat Co., Pomona, Cal.

REGISTRATION No. 69.

Magic Lawn and Garden
Tankage

### Standard Fertilizer Co., Los Angeles, Cal.

REGISTRATION No. 60.

Bone Meal
Fish Fertilizer
Ground Kelp
Standard No. 1
Standard No. 2
Standard No. 3
Standard No. 4
Standard No. 5
Standard No. 6
Standard No. 7

### Swift & Co., Chicago, Ill.

REGISTRATION No. 5.

Swift's Diamond "C"
Swift's Diamond "D"
Swift's Diamond "E"
Swift's Diamond "K"
Swift's Diamond "L"
Swift's High Grade Blood
Swift's High Grade Tankage
Swift's Special Bone Meal

### Union Fertilizer Co., Los Angeles, Cal.

REGISTRATION No. 9.

Blood
Bone Meal
Fruiting Fertilizer
Guano
Muriate of Potash
Nitrate of Lime
Nitrate of Soda
Nursery Fertilizer
Special Fruiting Fertilizer
Sulfate of Potash
Tankage
Union No. 1
Union No. 2
Union No. 3

### Union Superphosphate Co., San Francisco, Cal.

REGISTRATION No. 31.

Superphosphate, Cresco
Superphosphate, Pacific

### J. M. Waterman Chemical Co., Los Angeles, Cal.

REGISTRATION No. 75.

Blood
Bone Meal
Gypsum
Grape Pomace
Muriate of Potash
Nitrate of Soda
Sulfate of Potash
Superphosphate
Special mixtures

### Western Fertilizer Co., San Francisco, Cal.

REGISTRATION No. 68.

Wizard
Wonder

### Western Meat Co., San Francisco, Cal.

REGISTRATION No. 11.

Brands A, B, C, D, E, F, G, H, I, K, L, M, O, R, S
Fair Green
Lemon Special
Nitrate of Soda
Odorless Lawn Dressing
Putting Green
Sulfate of Potash
Superphosphate
Tankage

## Report of Analyses.

Available phosphoric acid is not determined in bone meal, tankage, and Thomas phosphate powder, unless requested. The fineness of these materials is determined, fine and medium bone being separated by a sieve of 50 meshes to the inch; tankage by a 25-mesh sieve; and Thomas phosphate powder by a 100-mesh sieve.

Nitrogen in ammonium salts will, in some cases, be found reported when nitrogen in this form is not guaranteed. In some of such cases this form of nitrogen is produced by conversion of organic nitrogen during process of manufacture, and is not to be considered a deviation from guaranty of materials used. Guanos carry more or less nitrogen in nitrates and ammonium salts, and when any appreciable quantity of guano is used the manufacturer should take into account the fact that some nitrogen will show as nitrates and ammonium salts. The failure to take this into consideration may perhaps account for the appearance of these forms of nitrogen in some samples in which only organic nitrogen was guaranteed.

The percentage of chlorin is given when it exceeds 0.50 per cent. It is a matter of only technical interest whether chlorin present is from muriate of potash, kainit, or from common salt that may be in some of the materials used. If a manufacturer uses sulfate of potash and uses a tankage with it containing a large amount of chlorin, from a practical standpoint he has lowered the grade of his fertilizer just as much as if he had used muriate of potash instead of sulfate of potash. Chlorin from all other sources is as objectionable as from muriate of potash. However, if muriate of potash is found when sulfate is guaranteed, the fact will be published.

The following abbreviations are used in the tables: Bl = blood, Bn = bone, Fs = fish, G = guano, H = hoof, Min. Phos. = mineral phosphate, Super = superphosphates, T = tankage, CSM = cotton seed meal.

Guarantees are entered in italics. Deficiencies greater than allowed by law are entered in bold type.

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Agricultural Chemical Works, Los Angeles, Cal.** | | |
| 6076 | "A" | J. M. Webster, Upland | 29.02 |
| 6145 | "A" | E. A. Moore, Redlands | 29.01 |
| 6274 | "A" | A. R. Hoefer, Orange | 28.92 |
| 6276 | "A" | R. R. Sherwood, Lordsburg | 29.47 |
| | *Guaranteed* | | *28.00* |
| 6083 | "B" | J. M. Webster, Upland | 31.15 |
| 6144 | "B" | E. A. Moore, Redlands | 30.57 |
| 6340 | "B" | E. A. Moore, Redlands | 31.87 |
| | *Guaranteed* | | *30.20* |
| 6092 | Bat Guano | Henry Fuller, Bryn Mawr | ---- |
| | *Sold on Station Analysis.* | | |
| 6056 | Blood | W. H. Collins, Covina | 59.62 |
| 6074 | Blood | J. M. Webster, Upland | 59.49 |
| 6140 | Blood | E. A. Moore, Redlands | 56.23 |
| 6253 | Blood | Gowen & Willard, Santa Ana | 61.34 |
| 6417 | Blood | D. F. Bremner, Upland | 61.42 |
| | *Guaranteed* | | *59.40* |
| 6139* | Bone Meal | E. A. Moore, Redlands | 37.21 |
| 6155* | Bone Meal | Union Commission Co., Santa Barbara | 37.44 |
| 6476* | Bone Meal | R. R. Sherwood, Orange | 39.73 |
| | *Guaranteed* | | *37.50* |
| 6287* | Bone Meal | Victoria Ave. Cit. Assn., Riverside | 39.38 |
| | *Guaranteed* | | *37.20* |
| 6058 | "C" | W. H. Collins, Covina | 35.68 |
| 6101 | "C" | J. M. Webster, Upland | 34.66 |
| 6143 | "C" | E. A. Moore, Redlands | 32.69 |
| 6218 | "C" | G. A. Herdeg, Riverside | 31.77 |
| 6342 | "C" | E. A. Moore, Redlands | 34.32 |
| | *Guaranteed* | | *33.40* |
| 6059 | "F" | W. H. Collins, Covina | 28.14 |
| 6266 | "F" | Gowen & Willard, Santa Ana | 28.73 |
| | *Guaranteed* | | *26.80* |
| 6272 | "G" | Gowen & Willard, Santa Ana | 27.61 |
| 6439 | "G" | J. D. McClenny, Pomona | 25.28 |
| | *Guaranteed* | | *24.60* |
| 6060 | "H" | W. H. Collins, Covina | 27.15 |
| 6075 | "H" | J. M. Webster, Upland | 26.14 |
| 6103 | "H" | J. M. Webster, Upland | 25.24 |
| 6277 | "H" | R. R. Sherwood, Lordsburg | 26.17 |
| | *Guaranteed* | | *26.60* |
| 6100 | "K" | J. M. Webster, Upland | 29.90 |
| 6278 | "K" | R. R. Sherwood, Lordsburg | 28.62 |
| | *Guaranteed* | | *27.80* |

*6139—51% fine.
*6155—52% fine.
*6476—47% fine.
*6287—58% fine.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6076 | 5.88 | 3.22 | 9.10 | ---------- | 1.42 | ---- | 2.42 | ---------- | 3.80 | 3.06 | 3.06 | 0.90 |
| 6145 | 4.46 | 4.14 | 8.60 | ---------- | 0.92 | ---- | 2.83 | ---------- | 3.75 | 3.22 | 3.22 | 0.55 |
| 6274 | 6.42 | 2.28 | 8.70 | ---------- | 1.33 | ---- | 2.47 | ---------- | 3.80 | ---- | 3.23 | 1.45 |
| 6276 | 5.64 | 3.36 | 9.00 | ---------- | 0.95 | ---- | 2.83 | ---------- | 3.78 | 3.22 | 3.22 | 0.82 |
| ---- | *5.00* | *3.00* | *8.00* | *Bn, Super, T* | *2.00* | ---- | *2.00* | *Bat G, Bl, Bn* | *4.00* | *3.00* | *3.00* | ---- |
| 6083 | 5.43 | 3.02 | 8.45 | ---------- | 1.50 | ---- | 3.32 | ---------- | 4.82 | 2.40 | 2.40 | 0.70 |
| 6144 | 5.41 | 3.54 | 8.95 | ---------- | 2.42 | ---- | 2.47 | ---------- | 4.89 | 2.20 | 2.20 | ---- |
| 6340 | 3.13 | 4.92 | 8.05 | ---------- | 1.38 | ---- | 3.65 | ---------- | 5.03 | 2.44 | 2.44 | 0.90 |
| ---- | *4.00* | *4.00* | *8.00* | *Bn, Super, T* | *2.00* | ---- | *3.00* | *Bat G, Bl, Bn* | *5.00* | *2.00* | *2.00* | ---- |
| 6092 | ---- | ---- | 6.45 | ---------- | 0.49 | 1.52 | 4.91 | ---------- | 6.92 | ---- | 2.22 | ---- |
| 6056 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.55 | ---------- | 13.55 | ---- | ---- | ---- |
| 6074 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.52 | ---------- | 13.52 | ---- | ---- | ---- |
| 6140 | ---- | ---- | ---- | ---------- | ---- | ---- | 12.78 | ---------- | 12.78 | ---- | ---- | ---- |
| 6253 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.94 | ---------- | 13.94 | ---- | ---- | ---- |
| 6417 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.96 | ---------- | 13.96 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *13.50* | ---------- | *13.50* | ---- | ---- | ---- |
| 6139 | ---- | ---- | 22.40 | ---------- | ---- | ---- | 4.06 | ---------- | 4.06 | ---- | ---- | ---- |
| 6155 | ---- | ---- | 22.70 | ---------- | ---- | ---- | 4.05 | ---------- | 4.05 | ---- | ---- | ---- |
| 6476 | ---- | ---- | 24.40 | ---------- | ---- | ---- | 4.23 | ---------- | 4.23 | ---- | ---- | ---- |
| ---- | ---- | ---- | *23.00* | ---------- | ---- | ---- | *4.00* | ---------- | *4.00* | ---- | ---- | ---- |
| 6287 | ---- | ---- | 24.30 | ---------- | ---- | ---- | 4.17 | ---------- | 4.17 | ---- | ---- | ---- |
| ---- | ---- | ---- | *25.00* | ---------- | ---- | ---- | *3.50* | ---------- | *3.50* | ---- | ---- | ---- |
| 6058 | 5.13 | 2.82 | 7.95 | ---------- | 1.36 | ---- | 4.46 | ---------- | 5.82 | ---- | 2.72 | 1.07 |
| 6101 | 5.08 | 3.62 | 8.70 | ---------- | 1.57 | ---- | 4.25 | ---------- | 5.82 | ---- | 1.98 | 1.52 |
| 6143 | 4.96 | 3.14 | 8.10 | ---------- | 3.05 | ---- | 2.81 | ---------- | 5.86 | 1.92 | 1.92 | 0.82 |
| 6218 | 4.88 | 2.82 | 7.70 | ---------- | 1.99 | ---- | 3.34 | ---------- | 5.33 | 2.22 | 2.22 | 0.87 |
| 6342 | 2.93 | 4.82 | 7.75 | ---------- | 2.20 | ---- | 3.54 | ---------- | 5.74 | 2.72 | 2.72 | 0.85 |
| ---- | *4.00* | *4.00* | *8.00* | *Bn, Super, T* | *3.00* | ---- | *3.00* | *Bat G, Bl, Bn* | *6.00* | *2.00* | *2.00* | ---- |
| 6059 | 6.20 | 2.60 | 8.80 | ---------- | 0.82 | ---- | 2.20 | ---------- | 3.02 | 4.18 | 4.18 | 0.60 |
| 6266 | 6.35 | 2.50 | 8.85 | ---------- | 0.77 | ---- | 2.40 | ---------- | 3.17 | 4.11 | 4.11 | 0.75 |
| ---- | *6.00* | *2.00* | *8.00* | *Bn, Super, T* | *1.00* | ---- | *2.00* | *Bat G, Bl, Bn* | *3.00* | *4.00* | *4.00* | ---- |
| 6272 | 7.51 | 4.54 | 12.05 | ---------- | 0.84 | ---- | 2.19 | ---------- | 3.03 | 2.44 | 2.44 | ---- |
| 6439 | 4.50 | 6.40 | 10.90 | ---------- | 0.93 | ---- | 1.97 | ---------- | 2.90 | 2.11 | 2.11 | 0.55 |
| ---- | *6.00* | *4.00* | *10.00* | *Bn, Super, T* | *1.00* | ---- | *2.00* | *Bat G, Bl, Bn* | *3.00* | *2.00* | *2.00* | ---- |
| 6060 | 6.74 | 4.26 | 11.00 | ---------- | 0.80 | ---- | 1.96 | ---------- | 2.76 | 3.23 | 3.23 | 0.70 |
| 6075 | 6.55 | 4.10 | 10.65 | ---------- | 0.98 | ---- | 1.90 | ---------- | 2.88 | 2.72 | 2.72 | 0.75 |
| 6103 | 5.95 | 3.50 | 9.45 | ---------- | ---- | ---- | 2.58 | ---------- | 2.58 | 2.95 | 2.95 | 0.95 |
| 6277 | 6.12 | 3.68 | 9.80 | ---------- | ---- | ---- | 2.76 | ---------- | 2.76 | 2.88 | 2.88 | 0.80 |
| ---- | *6.00* | *4.00* | *10.00* | *Bn, Super, T* | *1.00* | ---- | *2.00* | *Bat G, Bl, Bn* | *3.00* | *3.00* | *3.00* | ---- |
| 6100 | 5.31 | 4.54 | 9.85 | ---------- | 1.56 | ---- | 2.72 | ---------- | 4.28 | 2.31 | 2.31 | ---- |
| 6278 | 6.20 | 4.10 | 10.30 | ---------- | 0.70 | ---- | 3.13 | ---------- | 3.83 | 1.98 | 1.98 | 0.95 |
| ---- | *6.00* | *4.00* | *10.00* | *Bn, Super, T* | *2.00* | ---- | *2.00* | *Bat G, Bl, Bn* | *4.00* | *2.00* | *2.00* | ---- |

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| **Agricultural Chemical Works—** Continued. | | | |
| 6078 | "L" | J. M. Webster, Upland | 29.86 |
| 6275 | "L" | A. R. Hoefer, Orange | 32.15 |
| | *Guaranteed* | | *30.60* |
| 6142 | Lawn | E. A. Moore, Redlands | 25.68 |
| 6219 | Lawn | G. A. Herdeg, Riverside | 25.93 |
| 6265 | Lawn | Gowen & Willard, Santa Ana | 27.10 |
| | *Guaranteed* | | *24.50* |
| 6279 | "M" | R. R. Sherwood, Lordsburg | 27.08 |
| | *Guaranteed* | | *27.30* |
| 6061 | "N" | W. H. Collins, Covina | 38.29 |
| 6079 | "N" | J. M. Webster, Upland | 37.85 |
| | *Guaranteed* | | *38.00* |
| 6420 | Nitrate and Bone | Geo. T. Vance, Jr., Upland | 45.36 |
| | *Guaranteed* | | *46.40* |
| 6341 | "O" | E. A. Moore, Redlands | 29.98 |
| | *Guaranteed* | | *26.00* |
| 6138 | Special | E. A. Moore, Redlands | 59.68 |
| | *Guaranteed* | | *61.20* |
| 6343 | Special | E. A. Moore, Redlands | 40.39 |
| | *Guaranteed* | | *40.60* |
| 6419 | Special | W. J. Stowe et al., Los Angeles | 27.58 |
| 6455 | Special | Erasmus Wilson, San Gabriel | 29.42 |
| 6477 | Special | R. R. Sherwood, Orange | 28.80 |
| | *Guaranteed* | | *28.00* |
| 6440 | Special | J. D. McClenny, Pomona | 27.90 |
| 6479 | Special | R. R. Sherwood, Orange | 25.75 |
| | *Guaranteed* | | *25.60* |
| 6478 | Special | R. R. Sherwood, Orange | 31.24 |
| | *Guaranteed* | | *32.20* |
| 6146 | Summer B | E. A. Moore, Redlands | 31.94 |
| | *Guaranteed* | | *31.60* |
| 6148 | Summer C | E. A. Moore, Redlands | 38.42 |
| | *Guaranteed* | | *38.00* |
| 6273* | Tankage | A. R. Hoefer, Orange | 31.74 |
| | *Guaranteed* | | *31.92* |
| 6281* | Tankage | J. D. McClenny, Pomona | 30.17 |
| | *Guaranteed* | | *29.40* |
| 6057 | Tankage Fertilizer | W. H. Collins, Covina | 35.34 |
| 6141 | Tankage Fertilizer | E. A. Moore, Redlands | 36.14 |
| 6280 | Tankage Fertilizer | J. D. McClenny, Pomona | 35.80 |
| 6438 | Tankage Fertilizer | J. D. McClenny, Pomona | 36.43 |
| | *Guaranteed* | | *37.24* |

*6273—71% fine.
*6281—78% fine.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6078 | 6.56 | 3.74 | 10.30 | ---------- | 1.00 | ---- | 1.86 | ---------- | 2.86 | 4.79 | 4.79 | 0.67 |
| 6275 | 6.05 | 4.00 | 10.05 | ---------- | 1.12 | ---- | 2.00 | ---------- | 3.12 | 5.56 | 5.56 | 0.75 |
| ---- | *5.00* | *5.00* | *10.00* | *Bn, Super, T* | *1.00* | ---- | *2.00* | *Bat G, Bl, Bn* | *3.00* | *5.00* | *5.00* | ---- |
| 6142 | 4.83 | 5.42 | 10.25 | ---------- | ---- | ---- | 2.59 | ---------- | 2.59 | ---- | 2.79 | 2.70 |
| 6219 | 4.15 | 6.86 | 11.00 | ---------- | ---- | ---- | 2.57 | ---------- | 2.57 | 2.62 | 2.62 | ---- |
| 6265 | 6.09 | 4.96 | 11.05 | ---------- | ---- | ---- | 2.89 | ---------- | 2.89 | ---- | 2.51 | 1.77 |
| ---- | *5.00* | *5.00* | *10.00* | *Super, T* | ---- | ---- | *2.50* | *Bat G, Bl, Bn* | *2.50* | ---- | *2.50* | ---- |
| 6279 | 8.00 | 4.20 | 12.20 | ---------- | ---- | ---- | 2.42 | ---------- | 2.42 | 2.97 | 2.97 | 0.70 |
| ---- | *7.00* | *5.00* | *12.00* | *Bn, Super, T* | ---- | ---- | *2.50* | *Bat G, Bl, Bn* | *2.50* | *3.00* | *3.00* | ---- |
| 6061 | 6.97 | 2.78 | 9.75 | ---------- | 1.06 | ---- | 3.91 | ---------- | 4.97 | ---- | 4.85 | 1.25 |
| 6079 | 6.74 | 2.56 | 9.30 | ---------- | 1.34 | ---- | 3.64 | ---------- | 4.98 | 4.95 | 4.95 | 0.90 |
| ---- | *5.00* | *5.00* | *10.00* | *Bn, Super, T* | *2.00* | ---- | *3.00* | *Bat G, Bl, Bn* | *5.00* | *5.00* | *5.00* | ---- |
| 6420 | ---- | ---- | 1.20 | ---------- | 13.94 | ---- | 0.18 | ---------- | **14.12** | ---- | ---- | ---- |
| ---- | ---- | ---- | *.50* | *Bn* | *14.50* | ---- | ---- | ---------- | *14.50* | ---- | ---- | ---- |
| 6341 | 4.06 | 4.34 | 8.40 | ---------- | 1.06 | ---- | 3.34 | ---------- | 4.40 | 2.50 | 2.50 | 0.75 |
| ---- | *5.00* | *3.00* | *8.00* | *Bn. Super, T* | *2.00* | ---- | *2.00* | *Bat G, Bl, Bn* | *4.00* | *2.00* | *2.00* | ---- |
| 6138 | ---- | ---- | ---- | ---------- | ---- | 3.98 | 10.67 | ---------- | **14.65** | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | *4.00* | *11.00* | *Bl* | *15.00* | ---- | ---- | ---- |
| 6343 | ---- | ---- | 9.25 | ---------- | 1.83 | ---- | 6.24 | ---------- | 8.07 | ---- | ---- | ---- |
| ---- | ---- | ---- | *10.00* | *Bn, Fs, G, T* | *2.00* | ---- | *6.00* | *Bl, Bn, Fs, G, T* | 8.00 | ---- | ---- | ---- |
| 6419 | ---- | ---- | 10.20 | ---------- | 1.80 | ---- | 3.01 | ---------- | 4.81 | ---- | ---- | ---- |
| 6455 | ---- | ---- | 10.05 | ---------- | 1.00 | ---- | 4.09 | ---------- | 5.09 | ---- | ---- | ---- |
| 6477 | ---- | ---- | 10.00 | ---------- | 1.12 | ---- | 3.86 | ---------- | 4.98 | ---- | ---- | ---- |
| ---- | ---- | ---- | *10.00* | *Bn, Super, T* | *2.00* | ---- | *3.00* | *Bat G, Bl, Bn, Fs* | *5.00* | ---- | ---- | ---- |
| 6440 | ---- | ---- | 12.60 | ---------- | 1.50 | ---- | 2.80 | ---------- | 4.30 | ---- | ---- | ---- |
| 6479 | ---- | ---- | 11.75 | ---------- | 1.08 | ---- | 2.79 | ---------- | 3.87 | ---- | ---- | ---- |
| ---- | ---- | ---- | *12.00* | *Bn, Super, T* | *2.00* | ---- | *2.00* | *Bat G, Bl, Bn, Fs* | *4.00* | ---- | ---- | ---- |
| 6478 | ---- | ---- | 10.05 | ---------- | 1.54 | ---- | 4.11 | ---------- | **5.65** | ---- | ---- | ---- |
| ---- | ---- | ---- | *10.00* | *Bn, Super, T* | *2.00* | ---- | *4.00* | *Bat G, Bl, Bn, Fs* | *6.00* | ---- | ---- | ---- |
| 6146 | 4.43 | 3.32 | 7.75 | ---------- | ---- | ---- | 2.34 | ---------- | 2.34 | 7.57 | 7.57 | 0.75 |
| ---- | *5.00* | *3.00* | *8.00* | *Bn, Super, T* | ---- | ---- | *2.00* | *Bat G, Bl, Bn* | *2.00* | *8.00* | *8.00* | ---- |
| 6148 | 4.07 | 3.88 | 7.95 | ---------- | 1.73 | ---- | 2.18 | ---------- | 3.91 | 8.32 | 8.32 | 0.70 |
| ---- | *5.00* | *3.00* | *8.00* | *Bn, Super, T* | *2.00* | ---- | *2.00* | *Bat G, Bl, Bn* | *4.00* | *8.00* | *8.00* | ---- |
| 6273 | ---- | ---- | 13.60 | ---------- | ---- | ---- | 5.29 | ---------- | 5.29 | ---- | ---- | ---- |
| ---- | ---- | ---- | *13.50* | ---------- | ---- | ---- | *5.35* | ---------- | *5.35* | ---- | ---- | ---- |
| 6281 | ---- | ---- | 12.20 | ---------- | ---- | ---- | 5.15 | ---------- | 5.15 | ---- | ---- | ---- |
| ---- | ---- | ---- | *12.00* | ---------- | ---- | ---- | *5.00* | ---------- | *5.00* | ---- | ---- | ---- |
| 6057 | ---- | ---- | 8.00 | ---------- | ---- | 2.85 | 4.91 | ---------- | 7.76 | ---- | ---- | ---- |
| 6141 | ---- | ---- | 7.80 | ---------- | ---- | 2.88 | 5.11 | ---------- | **7.99** | ---- | ---- | ---- |
| 6280 | ---- | ---- | 8.15 | ---------- | ---- | 2.75 | 5.07 | ---------- | 7.82 | ---- | ---- | ---- |
| 6438 | ---- | ---- | 8.65 | ---------- | 2.33 | 1.23 | 4.52 | ---------- | 8.08 | ---- | ---- | ---- |
| ---- | ---- | ---- | *8.00* | ---------- | ---- | *4.00* | *4.00* | ---------- | *8.00* | ---- | ---- | ---- |

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **American Agricultural Chemical Co., Los Angeles, Cal.** | | |
| 6099 | Bradley's California Vegetable | G. L. Winterbotham, Riverside | 27.25 |
| 6220 | Bradley's California Vegetable | F. E. Dudderar, Covina | 29.50 |
| 6243 | Bradley's California Vegetable | M. R. Williams, Monrovia | 29.30 |
| | *Guaranteed* | | *27.46* |
| 6168 | Bradley's Grain No. 2 | Fresno Fuel Co., Fresno | 23.79 |
| 6241 | Bradley's Grain No. 2 | M. R. Williams, Monrovia | 21.44 |
| | *Guaranteed* | | *20.90* |
| 6130 | Bradley's Lawn | E. M. Cope, Commercial Co., Redlands | 27.31 |
| 6167 | Bradley's Lawn | Fresno Fuel Co., Fresno | 28.28 |
| 6217 | Bradley's Lawn | Morris & Snow Seed Co., Los Angeles | 27.15 |
| 6221 | Bradley's Lawn | F. E. Dudderar, Covina | 27.55 |
| 6242 | Bradley's Lawn | M. R. Williams, Monrovia | 27.26 |
| 6456 | Bradley's Lawn | A. W. Blake, Pasadena | 26.13 |
| 6481 | Bradley's Lawn | Campbell Seed Store, Pasadena | 26.62 |
| 6527 | Bradley's Lawn | L. M. Jacobs Co., Pasadena | 25.56 |
| | *Guaranteed* | | *26.12* |
| 6251 | Bradley's Lemon Tree | Pacific Wood & Coal Co., San Diego | 27.65 |
| | *Guaranteed* | | *26.12* |
| 6102 | Bradley's Nursery Stock | G. L. Winterbotham, Riverside | 26.51 |
| 6134 | Bradley's Nursery Stock | E. C. Robinson, Pomona | 26.08 |
| 6166 | Bradley's Nursery Stock | Fresno Fuel Co., Fresno | 28.77 |
| 6214 | Bradley's Nursery Stock | W. H. Grant, Porterville | 29.72 |
| 6222 | Bradley's Nursery Stock | F. E. Dudderar, Covina | 27.35 |
| 6282 | Bradley's Nursery Stock | F. E. Dudderar, Covina | 27.81 |
| 6344 | Bradley's Nursery Stock | R. S. Thompson, Highland | 28.38 |
| 6393 | Bradley's Nursery Stock | R. H. Hille, San Fernando | 27.88 |
| 6403 | Bradley's Nursery Stock | W. S. Fenton, Ontario | 26.33 |
| | *Guaranteed* | | *26.12* |
| 6129 | Bradley's Orange and Lemon | E. M. Cope Commercial Co., Redlands | 28.17 |
| | *Guaranteed* | | *26.74* |
| | **Armour Fertilizer Works, Los Angeles, Cal.** | | |
| 6227 | Armour's A | Factory at Porterville | 32.13 |
| | *Guaranteed* | | *28.80* |
| 6228 | Armour's B | Factory at Porterville | 43.18 |
| | *Guaranteed* | | *37.80* |
| 6229 | Armour's C | Factory at Porterville | 70.40 |
| | *Guaranteed* | | *68.60* |
| 6055 | Blood | Miss A. R. Brown, Covina | 61.60 |
| | *Guaranteed* | | *62.30* |
| 6069 | Blood | N. H. Garrison, Ontario | 62.13 |
| | *Guaranteed* | | *62.35* |
| 6121 | Blood | E. F. Wilson, Upland | 60.68 |
| | *Guaranteed* | | *61.85* |

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6099 | 8.29 | 0.76 | 9.05 | ---------- | 1.83 | 0.77 | 0.64 | ---------- | 3.24 | 4.05 | 4.05 | ---- |
| 6220 | 8.50 | 0.70 | 9.20 | ---------- | 2.06 | 0.75 | 0.83 | ---------- | 3.64 | 4.37 | 4.37 | ---- |
| 6243 | 8.12 | 1.38 | 9.50 | ---------- | 2.01 | 0.58 | 0.92 | ---------- | 3.51 | 4.30 | 4.30 | ---- |
| ---- | *8.00* | *1.00* | *9.00* | *Bn, Super* | *1.90* | *0.60* | *0.80* | *Bat G, Bl, Bn, T* | *3.30* | *4.00* | *4.00* | ---- |
| 6168 | 8.38 | 0.32 | 9.70 | ---------- | 1.65 | 0.35 | 0.99 | ---------- | 2.99 | 2.25 | 2.25 | ---- |
| 6241 | 8.52 | 0.88 | 9.40 | ---------- | 1.13 | 0.49 | 0.86 | ---------- | 2.48 | 2.09 | 2.09 | ---- |
| ---- | *8.00* | *1.00* | *9.00* | *Bn, Super* | *1.26* | *0.31* | *0.90* | *Bat G, Bl, Bn, T* | *2.47* | *2.00* | *2.00* | ---- |
| 6130 | 8.87 | 1.28 | 10.15 | ---------- | 2.25 | 0.74 | 1.15 | ---------- | 4.14 | 1.89 | 1.89 | ---- |
| 6167 | 9.02 | 0.98 | 10.00 | ---------- | 2.63 | 0.71 | 0.98 | ---------- | 4.32 | 2.24 | 2.24 | ---- |
| 6217 | 9.15 | 1.20 | 10.35 | ---------- | 2.26 | 0.76 | 1.06 | ---------- | 4.08 | 1.86 | 1.86 | 0.52 |
| 6221 | 9.48 | 1.32 | 10.80 | ---------- | 2.35 | 0.77 | 1.05 | ---------- | 4.17 | 1.72 | 1.72 | ---- |
| 6242 | 9.34 | 1.36 | 10.70 | ---------- | 2.31 | 0.77 | 1.09 | ---------- | 4.17 | 1.60 | 1.60 | ---- |
| 6456 | 8.62 | 1.28 | 9.90 | ---------- | 2.28 | 0.95 | 0.91 | ---------- | 4.14 | 1.53 | 1.53 | ---- |
| 6481 | 8.93 | 1.22 | 10.15 | ---------- | 2.67 | 0.96 | 0.62 | ---------- | 4.25 | 1.63 | 1.63 | ---- |
| 6527 | 8.66 | 1.54 | 10.20 | ---------- | 2.29 | 0.90 | 0.76 | ---------- | 3.95 | 1.49 | 1.49 | ---- |
| ---- | *9.00* | *1.00* | *10.00* | *Bn, Super,* | *2.35* | *0.75* | *1.00* | *Bat G, Bl, Bn, T* | *4.10* | *1.50* | *1.50* | ---- |
| 6251 | 9.30 | 1.40 | 10.70 | ---------- | 2.12 | 0.78 | 1.30 | ---------- | 4.20 | 1.64 | 1.64 | ---- |
| ---- | *9.00* | *1.00* | *10.00* | *Bn, Super,* | *2.35* | *0.75* | *1.00* | *Bat G, Bl, Bn, T* | *4.10* | *1.50* | *1.50* | ---- |
| 6102 | 9.14 | 1.06 | 10.20 | ---------- | 2.39 | 0.79 | 0.95 | ---------- | 4.13 | 1.58 | 1.58 | ---- |
| 6134 | 8.93 | 1.12 | 10.05 | ---------- | 3.15 | ---- | 0.88 | ---------- | 4.03 | 1.63 | 1.63 | ---- |
| 6166 | 9.25 | 1.00 | 10.25 | ---------- | 2.63 | 0.74 | 0.92 | ---------- | 4.29 | 2.45 | 2.45 | ---- |
| 6214 | 9.59 | 1.36 | 10.95 | ---------- | 2.69 | 0.75 | 1.16 | ---------- | 4.60 | 1.99 | 1.99 | ---- |
| 6222 | 9.79 | 0.86 | 10.65 | ---------- | 2.56 | 0.70 | 0.97 | ---------- | 4.23 | 1.63 | 1.63 | ---- |
| 6282 | 9.08 | 1.32 | 10.40 | ---------- | 2.46 | 0.84 | 1.05 | ---------- | 4.35 | 1.74 | 1.74 | ---- |
| 6344 | 9.58 | 1.62 | 11.20 | ---------- | 2.48 | 0.78 | 1.12 | ---------- | 4.38 | 1.58 | 1.58 | ---- |
| 6393 | 8.85 | 1.60 | 10.45 | ---------- | 2.49 | 0.67 | 1.19 | ---------- | 4.35 | 1.68 | 1.68 | 0.52 |
| 6403 | 8.87 | 1.48 | 10.35 | ---------- | 2.22 | 0.92 | 0.94 | ---------- | 4.08 | 1.51 | 1.51 | ---- |
| ---- | *9.00* | *1.00* | *10.00* | *Bn, Super* | *2.35* | *0.75* | *1.00* | *Bat, G, Bl, Bn, T* | *4.10* | *1.50* | *1.50* | ---- |
| 6129 | 7.20 | 1.90 | 9.10 | ---------- | 2.14 | 0.66 | 0.90 | ---------- | 3.70 | 3.62 | 3.62 | ---- |
| ---- | *8.00* | *1.00* | *9.00* | *Bn, Super* | *2.20* | *0.70* | *0.80* | *Bat G, Bl, Bn, T* | *3.70* | *3.00* | *3.00* | ---- |
| 6227 | 14.08 | 5.22 | 19.30 | ---------- | 1.54 | ---- | 2.34 | ---------- | 3.88 | ---- | ---- | ---- |
| ---- | ---- | ---- | *15.00* | *Bn, Super* | *1.50* | ---- | *2.50* | *Bl, Bn* | *4.00* | ---- | ---- | ---- |
| 6228 | 11.95 | 2.80 | 14.75 | ---------- | ---- | ---- | ---- | ---------- | ---- | 14.95 | 14.95 | 0.85 |
| ---- | ---- | ---- | *12.00* | *Super* | ---- | ---- | ---- | ---------- | ---- | *13.50* | *13.50* | ---- |
| 6229 | ---- | ---- | ---- | ---------- | 2.41 | ---- | 5.62 | ---------- | 8.03 | 19.54 | 19.54 | 1.25 |
| ---- | ---- | ---- | ---- | ---------- | *3.00* | ---- | *5.00* | *Bl* | *8.00* | *19.00* | *19.00* | ---- |
| 6055 | ---- | ---- | ---- | ---------- | ---- | ---- | 14.00 | ---------- | 14.00 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *14.16* | ---------- | *14.16* | ---- | ---- | ---- |
| 6069 | ---- | ---- | ---- | ---------- | ---- | ---- | 14.12 | ---------- | 14.12 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *14.17* | ---------- | *14.17* | ---- | ---- | ---- |
| 6121 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.79 | ---------- | 13.79 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *13.83* | ---------- | *13.83* | ---- | ---- | ---- |

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Armour Fertilizer Works—** Continued. | | |
| 6136 | Blood | R. T. Murrell, Pomona | 59.14 |
| 6198 | Blood | E. F. Schrei, Lindsay | 60.85 |
| 6336 | Blood | W. T. Henderson, Riverside | 63.58 |
| 6351 | Blood | I. W. Freeman, Anaheim | 60.15 |
| 6538 | Blood | W. H. McCune, Jr., Monrovia | 58.70 |
| | *Guaranteed* | | *61.60* |
| 6238 | Blood | A. M. Seeley, Covina | 61.56 |
| | *Guaranteed* | | *60.24* |
| 6307 | Blood | A. P. Griffith Estate, Azusa | 59.44 |
| 6308 | Blood | A. P. Griffith Estate, Azusa | 59.22 |
| 6309 | Blood | A. P. Griffith Estate, Azusa | 59.22 |
| 6335 | Blood | W. T. Henderson, Riverside | 60.32 |
| 6380 | Blood | R. E. Fairchild, Redlands | 60.19 |
| 6413 | Blood | R. T. Murrell, Pomona | 60.28 |
| 6510 | Blood | Mrs. L. S. Poage, Azusa | 60.10 |
| | *Guaranteed* | | *60.28* |
| 6313 | Blood | Redlands Fruit Assn., Redlands | 62.39 |
| | *Guaranteed* | | *62.52* |
| 6379 | Blood | R. E. Fairchild, Redlands | 63.14 |
| | *Guaranteed* | | *62.26* |
| 6500 | Blood | Azusa Foot-Hill Cit. Co., Azusa | 57.90 |
| 6501 | Blood | Azusa Foot-Hill Cit. Co., Azusa | 58.61 |
| 6502 | Blood | Azusa Foot-Hill Cit. Co., Azusa | 58.96 |
| 6503 | Blood | Azusa Foot-Hill Cit. Co., Azusa | 57.51 |
| 6504 | Blood | Azusa Foot-Hill Cit. Co., Azusa | 58.78 |
| 6505 | Blood | Azusa Foot-Hill Cit. Co., Azusa | 58.56 |
| 6512 | Blood | Azusa Foot-Hill Cit. Co., Azusa | 58.78 |
| 6513 | Blood | Azusa Foot-Hill Cit. Co., Azusa | 58.87 |
| 6520 | Blood | W. H. Lindley, Ontario | 58.08 |
| | *Guaranteed* | | *57.20* |
| 6306 | Blood | A. M. Seeley, Covina | ---- |
| | *Sold on Station Analysis.* | | |
| 6119 | Bone, Blood and Potash | E. F. Wilson, Upland | 39.24 |
| 6240 | Bone, Blood and Potash | A. M. Seeley, Covina | 4014 |
| | *Guaranteed* | | *37.80* |
| 6204 | Bone, Blood and Potash | E. F. Schrei, Lindsay | 41.65 |
| | *Guaranteed* | | *38.30* |
| 6201* | Bone Meal | E. A. Zumbro, Riverside | 38.97 |
| | *Guaranteed* | | *34.65* |
| 6202* | Bone Meal | E. F. Schrei, Lindsay | 34.22 |
| | *Guaranteed* | | *31.20* |
| 6210* | Bone Meal | Chas. Fesler, Covina | 36.48 |
| 6268* | Bone Meal | S. S. Scofield, Azusa | 34.44 |
| 6269* | Bone Meal | Mrs. James Fleming, San Bernardino | 36.25 |
| | *Guaranteed* | | *33.15* |
| 6212* | Bone Meal | Azusa Foot-Hill Cit. Co., Azusa | 35.44 |
| 6213* | Bone Meal | Azusa Foot-Hill Cit. Co., Azusa | 35.83 |
| 6254* | Bone Meal | Azusa Foot-Hill Cit. Co., Azusa | 36.43 |

*6201—51% fine.
*6202—75% fine.
*6210—65% fine.
*6268—65% fine.
*6269—75% fine.
*6212—63% fine.
*6213—71% fine.
*6254—73% fine.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6136 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.44 | ---------- | 13.44 | ---- | ---- | ---- |
| 6198 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.83 | ---------- | 13.83 | ---- | ---- | ---- |
| 6336 | ---- | ---- | ---- | ---------- | ---- | ---- | 14.45 | ---------- | 14.45 | ---- | ---- | ---- |
| 6351 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.67 | ---------- | 13.67 | ---- | ---- | ---- |
| 6538 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.34 | ---------- | 13.34 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *14.00* | ---------- | *14.00* | ---- | ---- | ---- |
| 6238 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.99 | ---------- | 13.99 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *13.69* | ---------- | *13.69* | ---- | ---- | ---- |
| 6307 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.51 | ---------- | 13.51 | ---- | ---- | ---- |
| 6308 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.46 | ---------- | 13.46 | ---- | ---- | ---- |
| 6309 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.46 | ---------- | 13.46 | ---- | ---- | ---- |
| 6335 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.71 | ---------- | 13.71 | ---- | ---- | ---- |
| 6380 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.68 | ---------- | 13.68 | ---- | ---- | ---- |
| 6413 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.70 | ---------- | 13.70 | ---- | ---- | ---- |
| 6510 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.66 | ---------- | 13.66 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *13.70* | ---------- | *13.70* | ---- | ---- | ---- |
| 6313 | ---- | ---- | ---- | ---------- | ---- | ---- | 14.18 | ---------- | 14.18 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *14.21* | ---------- | *14.21* | ---- | ---- | ---- |
| 6379 | ---- | ---- | ---- | ---------- | ---- | ---- | 14.35 | ---------- | 14.35 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *14.15* | ---------- | *14.15* | ---- | ---- | ---- |
| 6500 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.16 | ---------- | 13.16 | ---- | ---- | ---- |
| 6501 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.32 | ---------- | 13.32 | ---- | ---- | ---- |
| 6502 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.40 | ---------- | 13.40 | ---- | ---- | ---- |
| 6503 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.07 | ---------- | 13.07 | ---- | ---- | ---- |
| 6504 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.36 | ---------- | 13.36 | ---- | ---- | ---- |
| 6505 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.31 | ---------- | 13.31 | ---- | ---- | ---- |
| 6512 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.36 | ---------- | 13.36 | ---- | ---- | ---- |
| 6513 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.38 | ---------- | 13.38 | ---- | ---- | ---- |
| 6520 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.20 | ---------- | 13.20 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *13.00* | ---------- | *13.00* | ---- | ---- | ---- |
| 6306 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.60 | ---------- | 13.60 | ---- | ---- | ---- |
| 6119 | 8.18 | 1.92 | 10.10 | ---------- | 0.98 | 0.95 | **2.09** | ---------- | 4.02 | ---- | **7.60** | **1.55** |
| 6240 | 8.26 | 2.14 | 10.40 | ---------- | 1.10 | 1.02 | 2.18 | ---------- | 4.30 | ---- | 7.42 | 1.05 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *1.00* | *1.00* | *2.00* | *Bl, Bn, G, T, C S Meal* | *4.00* | *7.00* | *7.00* | ---- |
| 6204 | 7.34 | 2.76 | 10.10 | ---------- | 1.62 | ---- | 3.09 | ---------- | 4.71 | 7.20 | 7.20 | 0.87 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *1.50* | ---- | *2.50* | *Bl, Bn, G, T* | *4.00* | *7.00* | *7.00* | ---- |
| 6201 | ---- | ---- | 23.70 | ---------- | ---- | ---- | 4.20 | ---------- | 4.20 | ---- | ---- | ---- |
| ---- | ---- | ---- | *21.00* | ---------- | ---- | ---- | *3.75* | ---------- | *3.75* | ---- | ---- | ---- |
| 6202 | ---- | ---- | 29.90 | ---------- | ---- | ---- | 1.74 | ---------- | 1.74 | ---- | ---- | ---- |
| ---- | ---- | ---- | *28.23* | ---------- | ---- | ---- | *1.38* | ---------- | *1.38* | ---- | ---- | ---- |
| 6210 | ---- | ---- | 27.00 | ---------- | ---- | ---- | 2.90 | ---------- | 2.90 | ---- | ---- | ---- |
| 6268 | ---- | ---- | 25.20 | ---------- | ---- | ---- | 2.80 | ---------- | 2.80 | ---- | ---- | ---- |
| 6269 | ---- | ---- | 26.70 | ---------- | ---- | ---- | 2.91 | ---------- | 2.91 | ---- | ---- | ---- |
| ---- | ---- | ---- | *24.00* | ---------- | ---- | ---- | *2.75* | ---------- | *2.75* | ---- | ---- | ---- |
| 6212 | ---- | ---- | 26.50 | ---------- | ---- | ---- | 2.76 | ---------- | 2.76 | ---- | ---- | ---- |
| 6213 | ---- | ---- | 26.70 | ---------- | ---- | ---- | 2.81 | ---------- | 2.81 | ---- | ---- | ---- |
| 6254 | ---- | ---- | 26.90 | ---------- | ---- | ---- | 2.91 | ---------- | 2.91 | ---- | ---- | ---- |

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Armour Fertilizer Works—** Continued. | | |
| 6255* | Bone Meal | Azusa Foot-Hill Cit. Co., Azusa | 36.28 |
| 6256* | Bone Meal | Azusa Foot-Hill Cit. Co., Azusa | 35.98 |
| 6257* | Bone Meal | Azusa Foot-Hill Cit. Co., Azusa | 35.98 |
| 6258* | Bone Meal | Azusa Foot-Hill Cit. Co., Azusa | 35.92 |
| 6259* | Bone Meal | Azusa Foot-Hill Cit. Co., Azusa | 35.65 |
| | *Guaranteed* | | *32.10* |
| 6249* | Bone Flour | H. P. Greene, San Diego | 33.32 |
| | *Guaranteed* | | *31.80* |
| 6349* | Bone Meal | I. W. Freeman, Anaheim | 34.53 |
| | *Guaranteed* | | *30.30* |
| 6250* | Bone Meal | H. P. Greene, San Diego | 34.71 |
| | *Guaranteed* | | *34.71* |
| 6430* | Bone Meal | E. M. Hudson, Los Angeles | 38.72 |
| | *Guaranteed* | | *36.60* |
| 6348* | Bone Meal | I. W. Freeman, Anaheim | 35.23 |
| | *Guaranteed* | | *36.00* |
| 6459* | Bone Meal | John Blake, Pasadena | 35.71 |
| | *Guaranteed* | | *38.20* |
| 6483* | Bone Meal | H. M. Bradley, Riverside | 38.15 |
| | *Guaranteed* | | *34.80* |
| 6120 | Cropmaker | E. F. Wilson, Upland | 30.94 |
| 6330 | Cropmaker | J. C. Boyd, Rialto | 30.83 |
| 6338 | Cropmaker | W. T. Henderson, Riverside | 31.49 |
| 6352 | Cropmaker | I. W. Freeman, Anaheim | 29.51 |
| 6381 | Cropmaker | R. E. Fairchild, Redlands | 31.71 |
| 6392 | Cropmaker | W. H. Wyckoff, Redlands | 29.08 |
| 6465 | Cropmaker | Tuolumne S. & W. P. Co., Sonora | 29.37 |
| | *Guaranteed* | | *27.80* |
| 6232 | Cropmaker Special | Factory at Porterville | 33.19 |
| | *Guaranteed* | | *28.30* |
| 6247 | Cropmaker Special | H. P. Green, San Diego | 29.45 |
| | *Guaranteed* | | *26.80* |
| 6357 | Cropmaker Special | I. W. Freeman, Anaheim | 28.08 |
| | *Guaranteed* | | *29.80* |
| 6466 | Cropmaker Special | Mrs. James Fleming, San Bernardino | 29.42 |
| 6537 | Cropmaker Special | W. H. McCune, Jr., Monrovia | 28.17 |
| | *Guaranteed* | | *28.30* |
| 6428 | Cotton Seed Meal | E. M. Hudson, Los Angeles | 28.31 |
| | *Guaranteed* | | *33.92* |
| 6284 | Cyanamid | A. M. Seeley, Covina | 59.71 |
| | *Guaranteed* | | *59.20* |
| 6451* | Fish Meal | E. M. Hudson, Los Angeles | 41.40 |
| | *Guaranteed* | | *40.95* |
| 6452* | Fish Meal | E. M. Hudson, Los Angeles | 40.87 |
| | *Guaranteed* | | *35.70* |
| 6453* | Fish Meal | E. M. Hudson, Los Angeles | 41.71 |
| | *Guaranteed* | | *43.46* |

*6250—55% fine. By mistake of manufacturer, since corrected. This was originally guaranteed nitrogen 2.50; phosphoric acid 22.00.
*6255—73% fine.
*6256—76% fine.
*6257—74% fine.
*6258—76% fine.
*6259—74% fine.
*6249—95% fine.
*6349—71% fine.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6255 | ---- | ---- | 27.20 | ---------- | ---- | ---- | 2.81 | ---------- | 2.81 | ---- | ---- | ---- |
| 6256 | ---- | ---- | 27.80 | ---------- | ---- | ---- | 2.61 | ---------- | 2.61 | ---- | ---- | ---- |
| 6257 | ---- | ---- | 27.10 | ---------- | ---- | ---- | 2.76 | ---------- | 2.76 | ---- | ---- | ---- |
| 6258 | ---- | ---- | 26.70 | ---------- | ---- | ---- | 2.83 | ---------- | 2.83 | ---- | ---- | ---- |
| 6259 | ---- | ---- | 27.80 | ---------- | ---- | ---- | 2.53 | ---------- | 2.53 | ---- | ---- | ---- |
| ---- | ---- | ---- | *24.00* | ---------- | ---- | ---- | *2.50* | ---------- | *2.50* | ---- | ---- | ---- |
| 6249 | ---- | ---- | 26.10 | ---------- | ---- | ---- | 2.34 | ---------- | 2.34 | ---- | ---- | ---- |
| ---- | ---- | ---- | *26.00* | ---------- | ---- | ---- | *2.00* | ---------- | *2.00* | ---- | ---- | ---- |
| 6349 | ---- | ---- | 28.10 | ---------- | ---- | ---- | 2.20 | ---------- | 2.20 | ---- | ---- | ---- |
| ---- | ---- | ---- | *22.00* | ---------- | ---- | ---- | *2.50* | ---------- | *2.50* | ---- | ---- | ---- |
| 6250 | ---- | ---- | 32.50 | ---------- | ---- | ---- | 1.30 | ---------- | 1.30 | ---- | ---- | ---- |
| ---- | ---- | ---- | *32.50* | ---------- | ---- | ---- | *1.30* | ---------- | *1.30* | ---- | ---- | ---- |
| 6430 | ---- | ---- | 23.70 | ---------- | ---- | ---- | 4.14 | ---------- | 4.14 | ---- | ---- | ---- |
| ---- | ---- | ---- | *22.00* | ---------- | ---- | ---- | *4.00* | ---------- | *4.00* | ---- | ---- | ---- |
| 6348 | ---- | ---- | 27.10 | ---------- | ---- | ---- | 2.58 | ---------- | 2.58 | ---- | ---- | ---- |
| ---- | ---- | ---- | *26.00* | ---------- | ---- | ---- | *3.00* | ---------- | *3.00* | ---- | ---- | ---- |
| 6459 | ---- | ---- | 28.20 | ---------- | ---- | ---- | 2.46 | ---------- | 2.46 | ---- | ---- | ---- |
| ---- | ---- | ---- | *28.40* | ---------- | ---- | ---- | *3.01* | ---------- | *3.01* | ---- | ---- | ---- |
| 6483 | ---- | ---- | 23.30 | ---------- | ---- | ---- | 4.09 | ---------- | 4.09 | ---- | ---- | ---- |
| ---- | ---- | ---- | *20.00* | ---------- | ---- | ---- | *4.00* | ---------- | *4.00* | ---- | ---- | ---- |
| 6120 | 8.94 | 1.46 | 10.40 | ---------- | 1.03 | 1.17 | 2.10 | ---------- | 4.30 | ---- | 2.86 | 1.08 |
| 6330 | 7.50 | 3.10 | 10.60 | ---------- | 1.15 | 1.05 | 2.14 | ---------- | 4.34 | ---- | 2.63 | 1.00 |
| 6338 | 7.71 | 2.94 | 10.65 | ---------- | 0.92 | 1.19 | 2.34 | ---------- | 4.45 | ---- | 2.66 | 1.15 |
| 6352 | 7.05 | 3.80 | 10.85 | ---------- | 0.96 | 1.04 | 2.10 | ---------- | 4.10 | 2.26 | 2.26 | 0.85 |
| 6381 | 8.18 | 2.82 | 11.00 | ---------- | 1.05 | 1.19 | 2.20 | ---------- | 4.44 | ---- | 2.70 | 1.05 |
| 6392 | 7.22 | 3.58 | 10.80 | ---------- | 1.02 | 1.06 | 2.01 | ---------- | 4.09 | ---- | 2.13 | 1.10 |
| 6465 | 7.34 | 3.06 | 10.40 | ---------- | 1.05 | 0.85 | 2.23 | ---------- | 4.13 | ---- | 2.28 | 1.17 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *1.00* | *1.00* | *2.00* | *Bl, Bn, G, T, C S Meal* | *4.00* | ---- | *2.00* | ---- |
| 6232 | 8.00 | 3.00 | 11.00 | ---------- | 1.54 | ---- | 2.89 | ---------- | 4.43 | 3.11 | 3.11 | 0.80 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *1.50* | ---- | *2.50* | *Bl, Bn, G, T* | *4.00* | *2.00* | *2.00* | ---- |
| 6247 | 8.66 | 2.24 | 10.90 | ---------- | 2.84 | ---- | 1.08 | ---------- | 3.92 | 3.01 | 3.01 | 0.95 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *3.00* | ---- | *1.00* | *Bl, Bn, G, T* | *4.00* | *2.00* | *2.00* | ---- |
| 6357 | ---- | ---- | 9.85 | ---------- | ---- | ---- | 3.85 | ---------- | 3.85 | ---- | 1.52 | 1.10 |
| ---- | ---- | ---- | *10.00* | *Bn* | ---- | ---- | *4.00* | *Bl, Bn, G, T* | *4.00* | *2.00* | *2.00* | ---- |
| 6466 | 7.18 | 3.42 | 10.60 | ---------- | 1.60 | ---- | 2.39 | ---------- | 3.99 | ---- | 2.36 | 1.75 |
| 6537 | 7.08 | 3.42 | 10.50 | ---------- | 1.79 | ---- | 2.05 | ---------- | 3.84 | ---- | 2.19 | 1.15 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *1.50* | ---- | *2.50* | *Bl, Bn, G, T* | *4.00* | *2.00* | *2.00* | ---- |
| 6428 | ---- | ---- | 2.55 | ---------- | ---- | ---- | 5.60 | ---------- | 5.60 | 1.50 | 1.50 | ---- |
| ---- | ---- | ---- | *2.80* | ---------- | ---- | ---- | *6.80* | ---------- | *6.80* | *1.70* | *1.70* | ---- |
| 6284 | ---- | ---- | ---- | ---------- | ---- | ---- | ---- | ---------- | 18.66 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | ---- | ---------- | *18.50* | ---- | ---- | ---- |
| 6451 | ---- | ---- | 7.30 | ---------- | ---- | ---- | 8.64 | ---------- | 8.64 | ---- | ---- | ---- |
| ---- | ---- | ---- | *6.00* | ---------- | ---- | ---- | *8.75* | ---------- | *8.75* | ---- | ---- | ---- |
| 6452 | ---- | ---- | 6.25 | ---------- | ---- | ---- | 8.69 | ---------- | 8.69 | ---- | ---- | ---- |
| ---- | ---- | ---- | *4.80* | ---------- | ---- | ---- | *7.70* | ---------- | *7.70* | ---- | ---- | ---- |
| 6453 | ---- | ---- | 7.70 | ---------- | ---- | ---- | 8.60 | ---------- | 8.60 | ---- | ---- | ---- |
| ---- | ---- | ---- | *6.89* | ---------- | ---- | ---- | *9.20* | ---------- | *9.20* | ---- | ---- | ---- |

*6430—51% fine.
*6348—72% fine.
*6459—76% fine.
*6483—48% fine.

*6451—67% fine.
*6452—63% fine.
*6453—74% fine.

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Armour Fertilizer Works—** Continued. | | |
| 6442 | Flower and Fern Food | E. M. Hudson, Los Angeles | 35.22 |
| | *Guaranteed* | | *34.00* |
| 6231 | Fruit and Vine | Factory at Porterville | 37.39 |
| | *Guaranteed* | | *34.60* |
| 6206 | Lawn and Garden | E. F. Schrei, Lindsay | 31.28 |
| 6226 | Lawn and Garden | Factory at Porterville | 35.10 |
| | *Guaranteed* | | *27.80* |
| 6244 | Lawn Special | H. P. Greene, San Diego | 26.47 |
| | *Guaranteed* | | *25.40* |
| 6360 | Lawn Special | I. W. Freeman, Anaheim | 27.39 |
| 6429 | Lawn Special | E. M. Hudson, Los Angeles | 25.82 |
| 6457 | Lawn Special | John Blake, Pasadena | 26.11 |
| 6473 | Lawn Special | I. W. Freeman, Anaheim | 23.00 |
| | *Guaranteed* | | *26.40* |
| 6245 | Special Lawn Special | H. P. Greene, San Diego | 25.66 |
| | *Guaranteed* | | *24.90* |
| 6118 | Nitrate of Soda | E. F. Wilson, Upland | 48.06 |
| 6137 | Nitrate of Soda | R. T. Murrell, Pomona | 48.32 |
| 6203 | Nitrate of Soda | E. F. Schrei, Lindsay | 48.51 |
| 6285 | Nitrate of Soda | A. M. Seeley, Covina | 50.27 |
| 6329 | Nitrate of Soda | J. C. Boyd, Rialto | 48.86 |
| 6339 | Nitrate of Soda | W. T. Henderson, Riverside | 48.51 |
| | *Guaranteed* | | *48.00* |
| 6054 | Orange Tree Manure | A. B. Hill, Pomona | 28.70 |
| 6207 | Orange Tree Manure | E. F. Schrei, Lindsay | 32.98 |
| 6233 | Orange Tree Manure | Factory at Porterville | 32.58 |
| 6382 | Orange Tree Manure | R. E. Fairchild, Redlands | 30.67 |
| 6474 | Orange Tree Manure | I. W. Freeman, Anaheim | 31.02 |
| | *Guaranteed* | | *28.10* |
| 6124 | Orange Tree Special | E. F. Wilson, Upland | 26.88 |
| 6458 | Orange Tree Special | John Blake, Pasadena | 28.88 |
| | *Guaranteed* | | *26.10* |
| 6358 | Special Orange Tree Special | Anaheim Cit. Fruit Assn., Anaheim | 27.72 |
| | *Guaranteed* | | *27.60* |
| 6359 | Special Orange Tree Manure | Garden Grove Lmb. Co., Garden Grove | 29.25 |
| | *Guaranteed* | | *28.10* |
| 6383 | Special Orange Tree Manure | R. E. Fairchild, Redlands | 31.00 |
| | *Guaranteed* | | *29.60* |
| 6098 | Special | C. L. Nye, Riverside | 38.77 |
| | *Guaranteed* | | *36.60* |

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6442 | 7.15 | 3.20 | 10.35 | ---------- | 2.47 | ---- | 2.78 | ---------- | 5.25 | 3.16 | 3.16 | 0.97 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *2.00* | ---- | *3.00* | *Bl, Bn, G, T* | *5.00* | *3.00* | *3.00* | ---- |
| 6231 | 5.82 | 2.58 | 8.40 | ---------- | 0.95 | ---- | 1.16 | ---------- | 2.11 | 10.96 | 10.96 | 0.85 |
| ---- | *6.00* | *2.00* | *8.00* | *Bn, G, Super* | *1.00* | ---- | *1.00* | *Bl, Bn, G, T, C S Meal* | *2.00* | *10.00* | *10.00* | ---- |
| 6206 | 4.24 | 2.36 | 6.60 | ---------- | 1.65 | ---- | 2.78 | ---------- | 4.43 | 4.19 | 4.19 | 0.70 |
| 6226 | 4.45 | 2.20 | 6.65 | ---------- | 1.36 | ---- | 3.12 | ---------- | 4.48 | 5.83 | 5.83 | 0.90 |
| ---- | *4.00* | *1.00* | *5.00* | *Bn, G, Super* | *1.50* | ---- | *2.50* | *Bl, Bn, G, T* | *4.00* | *4.00* | *4.00* | ---- |
| 6244 | 3.91 | 1.64 | 5.55 | ---------- | 2.05 | ---- | 2.27 | ---------- | 4.32 | 2.69 | 2.69 | 0.87 |
| ---- | *4.00* | *1.00* | *5.00* | *Bn, G, Super* | *2.00* | ---- | *2.50* | *Bl, Bn, G, T* | *4.50* | *2.00* | *2.00* | ---- |
| 6360 | 2.20 | 3.10 | 5.30 | ---------- | 1.20 | ---- | 3.50 | ---------- | 4.70 | ---- | 2.04 | 1.45 |
| 6429 | 3.05 | 2.30 | 5.35 | ---------- | 1.08 | ---- | 3.33 | ---------- | 4.41 | ---- | 1.78 | 1.30 |
| 6457 | 3.24 | 2.16 | 5.40 | ---------- | 1.27 | ---- | 3.14 | ---------- | 4.41 | ---- | 2.00 | 1.30 |
| 6473 | 3.01 | 1.94 | 4.95 | ---------- | 1.21 | ---- | 2.58 | ---------- | 3.79 | ---- | 1.92 | 1.02 |
| ---- | *4.00* | *1.00* | *5.00* | *Bn, G, Super* | *1.00* | ---- | *3.50* | *Bl, Bn, G, T, C S Meal* | *4.50* | *2.00* | *2.00* | ---- |
| 6245 | 4.26 | 1.14 | 5.40 | ---------- | 2.23 | ---- | 2.04 | ---------- | 4.27 | ---- | 2.55 | 1.05 |
| ---- | *4.00* | *1.00* | *5.00* | *Bn, G, Super* | *2.50* | ---- | *2.00* | *Bl, Bn, G, T, C S Meal* | *4.50* | *2.00* | *2.00* | ---- |
| 6118 | ---- | ---- | ---- | ---------- | 15.02 | ---- | ---- | ---------- | 15.02 | ---- | ---- | ---- |
| 6137 | ---- | ---- | ---- | ---------- | 15.10 | ---- | ---- | ---------- | 15.10 | ---- | ---- | ---- |
| 6203 | ---- | ---- | ---- | ---------- | 15.16 | ---- | ---- | ---------- | 15.16 | ---- | ---- | ---- |
| 6285 | ---- | ---- | ---- | ---------- | 15.71 | ---- | ---- | ---------- | 15.71 | ---- | ---- | ---- |
| 6329 | ---- | ---- | ---- | ---------- | 15.27 | ---- | ---- | ---------- | 15.27 | ---- | ---- | ---- |
| 6339 | ---- | ---- | ---- | ---------- | 15.16 | ---- | ---- | ---------- | 15.16 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | *15.00* | ---- | ---- | ---------- | *15.00* | ---- | ---- | ---- |
| 6054 | 8.51 | 1.24 | 9.75 | ---------- | 1.00 | 0.50 | 1.53 | ---------- | 3.03 | ---- | 4.35 | 1.65 |
| 6207 | 7.85 | 2.70 | 10.55 | ---------- | 1.63 | ---- | 1.92 | ---------- | 3.55 | 5.10 | 5.10 | 0.90 |
| 6233 | 8.61 | 2.74 | 11.35 | ---------- | 1.55 | ---- | 1.81 | ---------- | 3.36 | 4.90 | 4.90 | ---- |
| 6382 | 8.24 | 2.16 | 10.40 | ---------- | 1.17 | 0.55 | 1.62 | ---------- | 3.34 | 4.50 | 4.50 | 0.97 |
| 6474 | 7.11 | 3.64 | 10.75 | ---------- | 1.49 | ---- | 1.47 | ---------- | 2.96 | 5.20 | 5.20 | 0.80 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *1.00* | *0.50* | *1.50* | *Bl, Bn, G, T, C S Meal* | *3.00* | *4.00* | *4.00* | ---- |
| 6124 | 7.96 | 2.34 | 10.30 | ---------- | 1.15 | 0.59 | 1.29 | ---------- | 3.03 | 3.31 | 3.31 | 0.80 |
| 6458 | 7.47 | 3.78 | 11.25 | ---------- | 0.71 | 0.55 | 1.82 | ---------- | 3.08 | 3.54 | 3.54 | 0.82 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *1.00* | *0.50* | *1.50* | *Bl, Bn, G, T* | *3.00* | *3.00* | *3.00* | ---- |
| 6358 | ---- | ---- | 10.00 | ---------- | ---- | ---- | 3.09 | ---------- | 3.09 | 2.87 | 2.87 | 0.80 |
| ---- | ---- | ---- | *10.00* | *Bn,* | ---- | ---- | *3.00* | *Bl, Bn, T* | *3.00* | *3.00* | *3.00* | ---- |
| 6359 | 7.44 | 2.36 | 9.80 | ---------- | 1.54 | ---- | 1.69 | ---------- | 3.23 | 4.20 | 4.20 | 0.55 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *1.50* | ---- | *1.50* | *Bl, Bn, G, T* | *3.00* | *4.00* | *4.00* | ---- |
| 6383 | 8.49 | 2.36 | 10.85 | ---------- | 1.10 | 0.52 | 1.64 | ---------- | 3.26 | 4.58 | 4.58 | 0.90 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | ---- | ---- | ---- | ---------- | *3.00* | *4.00* | *4.00* | ---- |
| 6098 | 6.03 | 5.32 | 11.35 | ---------- | 0.76 | ---- | 2.11 | ---------- | 2.87 | 8.63 | 8.63 | 0.72 |
| ---- | *10.00* | ---- | ---- | *Bn, G, Super* | *1.00* | ---- | *2.00* | *Bl, Bn, G, T* | *3.00* | *8.00* | *8.00* | ---- |

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Armour Fertilizer Works—Continued.** | | |
| 6126 | Special | E. F. Wilson, Upland | 38.67 |
| | *Guaranteed* | | *36.60* |
| 6122 | Special | E. F. Wilson, Upland | 33.53 |
| 6236 | Special | A. M. Seeley, Covina | 36.37 |
| | *Guaranteed* | | *32.40* |
| 6125 | Special | E. F. Wilson, Upland | 33.70 |
| | *Guaranteed* | | *31.50* |
| 6199 | Special | E. F. Schrei, Lindsay | 36.46 |
| | *Guaranteed* | | *34.70* |
| 6205 | Special | E. F. Schrei, Lindsay | 38.94 |
| | *Guaranteed* | | *34.10* |
| 6208 | Special, Powers | Factory at Porterville | 43.82 |
| | *Guaranteed* | | *40.10* |
| 6225 | Special | Factory at Porterville | 45.08 |
| | *Guaranteed* | | *44.30* |
| 6246 | Special | H. P. Greene, San Diego | 39.58 |
| | *Guaranteed* | | *38.80* |
| 6377 | Special | D. P. Stone, Redlands | 33.59 |
| | *Guaranteed* | | *33.00* |
| 6378 | Special | D. P. Stone, Redlands | 42.43 |
| | *Guaranteed* | | *41.00* |
| 6398 | Special | Mrs. M. Gray, Ontario | 33.01 |
| | *Guaranteed* | | *32.20* |
| 6450 | Special | E. M. Hudson, Los Angeles | 21.80 |
| | *Guaranteed* | | *21.20* |
| 6472 | Special Vegetable | I. W. Freeman, Anaheim | 26.23 |
| | *Guaranteed* | | *26.40* |
| 6237 | Special 6-8-1 | A. M. Seeley, Covina | 37.58 |
| 6471 | Special 6-8-1 | I. W. Freeman, Anaheim | 38.14 |
| 6486 | Special 6-8-1 | L. Drendel, Azusa | 34.93 |
| 6487 | Special 6-8-1 | Chas. Menefee, Covina | 34.75 |
| 6499 | Special 6-8-1 | Mrs. S. F. McDonald, Glendora | 34.56 |
| | *Guaranteed* | | *34.40* |
| 6109* | Tankage | E. F. Wilson, Upland | 42.47 |
| 6350* | Tankage | I. W. Freeman, Anaheim | 42.78 |
| | *Guaranteed* | | *45.35* |
| 6200* | Tankage | H. M. Bradley, Riverside | 30.65 |
| 6211* | Tankage | W. S. Hathaway, Riverside | 31.40 |
| 6239* | Tankage | A. M. Seeley, Covina | 31.98 |
| | *Guaranteed* | | *31.85* |

*6109—62% fine.
*6350—61% fine.
*6200—68% fine.
*6211—71% fine.
*6239—70% fine. Some hoof.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6126 | ---- | ---- | 20.10 | ---------- | ---- | ---- | 3.28 | ---------- | 3.28 | 3.40 | 3.40 | 0.60 |
| ---- | ---- | ---- | *20.00* | *Bn* | ---- | ---- | *3.00* | *Bl, Bn, T* | *3.00* | *3.00* | *3.00* | ---- |
| 6122 | ---- | ---- | 19.80 | ---------- | ---- | ---- | 2.25 | ---------- | 2.25 | 3.13 | 3.13 | ---- |
| 6236 | ---- | ---- | 21.40 | ---------- | ---- | ---- | 2.54 | ---------- | 2.54 | 3.22 | 3.22 | ---- |
| ---- | ---- | ---- | *20.00* | *Bn, Super* | ---- | ---- | *2.00* | *Bl, Bn, T* | *2.00* | *3.00* | *3.00* | ---- |
| 6125 | 7.85 | 2.30 | 10.15 | ---------- | 1.04 | 1.61 | 2.52 | ---------- | 5.17 | ---- | 2.75 | 1.65 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *1.00* | *1.50* | *2.50* | *Bl, Bn, G, T, C S Meal* | *5.00* | *2.00* | *2.00* | ---- |
| 6199 | 7.61 | 4.94 | 12.55 | ---------- | 0.60 | ---- | 1.53 | ---------- | 2.13 | 8.41 | 8.41 | 0.85 |
| ---- | *8.00* | *4.00* | *12.00* | *Bn, G, Super* | *0.50* | ---- | *1.50* | *Bn, G* | *2.00* | *8.00* | *8.00* | ---- |
| 6205 | 7.87 | 2.68 | 10.55 | ---------- | 1.52 | ---- | 1.92 | ---------- | 3.44 | ---- | 8.26 | 1.35 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *1.50* | ---- | *1.50* | *Bl, Bn, G, T, C S Meal* | *3.00* | *7.00* | *7.00* | ---- |
| 6208 | 7.44 | 2.66 | 10.10 | ---------- | 1.43 | ---- | 1.88 | ---------- | 3.31 | ---- | 11.13 | 1.22 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *1.50* | ---- | *1.50* | *Bl, Bn, G, T* | *3.00* | *10.00* | *10.00* | ---- |
| 6225 | 8.01 | 2.24 | 10.25 | ---------- | 1.69 | ---- | 2.14 | ---------- | 3.83 | ---- | 10.73 | 1.32 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *1.50* | ---- | *2.50* | *Bl, Bn, G, T* | *4.00* | *10.00* | *10.00* | ---- |
| 6246 | 7.99 | 3.16 | 11.15 | ---------- | 2.92 | ---- | 0.98 | ---------- | 3.90 | 8.04 | 8.04 | 0.90 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *3.00* | ---- | *1.00* | *Bl, Bn, G, T* | *4.00* | *8.00* | *8.00* | ---- |
| 6377 | ---- | ---- | 13.80 | ---------- | 1.41 | ---- | 2.47 | ---------- | 3.88 | ---- | 3.14 | 1.17 |
| ---- | ---- | ---- | *13.00* | *Bn, G, Super* | *1.50* | ---- | *2.50* | *Bl, Bn, G, T* | *4.00* | *3.00* | *3.00* | ---- |
| 6378 | ---- | ---- | 13.70 | ---------- | 1.53 | ---- | 2.42 | ---------- | 3.95 | ---- | 7.52 | 1.15 |
| ---- | ---- | ---- | *13.00* | *Bn, G, Super* | *1.50* | ---- | *2.50* | *Bl, Bn, G, T* | *4.00* | *7.00* | *7.00* | ---- |
| 6398 | ---- | ---- | 8.55 | ---------- | ---- | ---- | 4.96 | ---------- | 4.96 | ---- | 2.24 | 1.47 |
| ---- | ---- | ---- | *8.00* | *Bn, Super* | ---- | ---- | *5.00* | *Bl, Bn, T* | *5.00* | *2.00* | *2.00* | ---- |
| 6450 | 5.67 | 2.98 | 8.65 | ---------- | 0.66 | ---- | 1.89 | ---------- | 2.55 | ---- | 1.98 | 2.00 |
| ---- | *6.00* | *2.00* | *8.00* | *Bn, Super* | *0.50* | ---- | *2.00* | *Bl, Bn, T* | *2.50* | *2.00* | *2.00* | ---- |
| 6472 | ---- | ---- | 5.55 | ---------- | 1.36 | ---- | 3.03 | ---------- | 4.39 | ---- | 2.08 | 1.35 |
| ---- | ---- | ---- | *5.00* | *Bn, G, Super* | *1.00* | ---- | *3.50* | *Bl, Bn, G, T, C S Meal* | *4.50* | *2.00* | *2.00* | ---- |
| 6237 | ---- | ---- | 9.20 | ---------- | ---- | ---- | 6.29 | ---------- | 6.29 | 1.44 | 1.44 | 0.62 |
| 6471 | ---- | ---- | 9.20 | ---------- | ---- | ---- | 6.39 | ---------- | 6.39 | 1.51 | 1.51 | 0.67 |
| 6486 | ---- | ---- | 8.70 | ---------- | ---- | ---- | 5.91 | ---------- | 5.91 | ---- | 1.14 | 1.70 |
| 6487 | ---- | ---- | 8.40 | ---------- | ---- | ---- | 5.93 | ---------- | 5.93 | ---- | 0.95 | 1.70 |
| 6499 | ---- | ---- | 8.35 | ---------- | ---- | ---- | 6.04 | ---------- | 6.04 | ---- | 0.84 | 1.20 |
| ---- | ---- | ---- | *8.00* | *Bn, G, C S Meal* | ---- | ---- | *6.00* | *Bl, Bn, G, T, C S Meal* | *6.00* | *1.00* | *1.00* | ---- |
| 6109 | ---- | ---- | 6.05 | ---------- | ---- | ---- | 9.08 | ---------- | 9.08 | ---- | ---- | ---- |
| 6250 | ---- | ---- | 6.15 | ---------- | ---- | ---- | 9.16 | ---------- | 9.16 | ---- | ---- | ---- |
| ---- | ---- | ---- | *5.50* | ---------- | ---- | ---- | *9.88* | ---------- | *9.88* | ---- | ---- | ---- |
| 6290 | ---- | ---- | 13.60 | ---------- | ---- | ---- | 5.03 | ---------- | 5.03 | ---- | ---- | ---- |
| 6211 | ---- | ---- | 14.25 | ---------- | ---- | ---- | 5.10 | ---------- | 5.10 | ---- | ---- | ---- |
| 6239 | ---- | ---- | 14.85 | ---------- | ---- | ---- | 5.14 | ---------- | 5.14 | ---- | ---- | ---- |
| ---- | ---- | ---- | *14.00* | ---------- | ---- | ---- | *5.25* | ---------- | *5.25* | ---- | ---- | ---- |

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Armour Fertilizer Works—** Continued. | | |
| 6292* | Tankage | Glendora Land Co., Glendora | 38.97 |
| | *Guaranteed* | | *32.35* |
| 6337* | Tankage | W. T. Henderson, Riverside | 36.88 |
| | *Guaranteed* | | *38.15* |
| 6327* | Tankage | E. F. Wilson, Upland | 40.69 |
| | *Guaranteed* | | *40.67* |
| 6388* | Tankage | R. T. Murrell, Pomona | 30.33 |
| | *Guaranteed* | | *29.40* |
| 6389* | Tankage | R. T. Murrell, Pomona | 39.54 |
| | *Guaranteed* | | *37.72* |
| 6397* | Tankage | H. G. Koster, Upland | 39.91 |
| | *Guaranteed* | | *41.15* |
| 6425* | Tankage | W. B. Cullen, Glendora | 44.49 |
| 6426* | Tankage | C. W. Richardson, Glendora | 45.00 |
| | *Guaranteed* | | *43.44* |
| 6427* | Tankage | E. M. Hudson, Los Angeles | 21.13 |
| | *Guaranteed* | | *19.84* |
| 6433* | Tankage | J. G. Gaylord, Ontario | 42.67 |
| | *Guaranteed* | | *43.33* |
| 6441* | Tankage | E. M. Hudson, Los Angeles | 52.16 |
| | *Guaranteed* | | *51.95* |
| 6482* | Tankage | J. W. Mays et al., Riverside | 35.92 |
| | *Guaranteed* | | *38.89* |
| 6506* | Tankage | John McInerney, San Dimas | 39.52 |
| | *Guaranteed* | | *39.20* |
| 6541* | Tankage | W. H. McCune, Jr., Monrovia | 43.87 |
| | *Guaranteed* | | *43.33* |
| 6304* | Tankage | J. W. Corwin et al., Highland | ---- |
| 6305* | Tankage | A. M. Seeley, Covina | ---- |
| | *Sold on Station Analysis.* | | |
| 6068 | 2-17-5 | W. A. Lucas, Cucamonga | 38.15 |
| | *Guaranteed* | | *33.70* |
| | **Rogers Brown & Co., Los Angeles, Cal.** | | |
| 6515* | Tankage | Orange Heights Fruit Assn., Corona | 41.24 |
| | *Guaranteed* | | *35.92* |
| 6421* | Whale Meat and Bone | W. C. Nickerson, Redlands | 39.20 |
| | *Guaranteed* | | *39.42* |
| 6435* | Whale Meat and Bone | Rialto Orange-Lemon Assn., Rialto | 44.15 |
| | *Guaranteed* | | *46.66* |

*6292—73% fine. Some hoof.
*6337—65% fine.
*6327—81% fine.
*6388—69% fine.
*6389—73% fine.
*6397—67% fine.
*6425—72% fine.
*6426—71% fine.
*6427—58% fine.
*6433—69% fine.
*6441—75% fine.
*6482—77% fine.
*6506—76% fine.
*6541—66% fine.
*6304—69% fine.
*6305—67% fine.
*6515—67% fine.
*6421—58% fine.
*6435—60% fine.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6292 | ---- | ---- | 7.55 | ---------- | ---- | ---- | 8.02 | ---------- | 8.02 | ---- | ---- | ---- |
| ---- | ---- | ---- | *6.86* | ---------- | ---- | ---- | *6.56* | ---------- | *6.56* | ---- | ---- | ---- |
| 6337 | ---- | ---- | 6.55 | ---------- | ---- | ---- | 7.69 | ---------- | 7.69 | ---- | ---- | ---- |
| ---- | ---- | ---- | *6.50* | ---------- | ---- | ---- | *8.00* | ---------- | *8.00* | ---- | ---- | ---- |
| 6327 | ---- | ---- | 15.05 | ---------- | ---- | ---- | 7.18 | ---------- | 7.18 | ---- | ---- | ---- |
| ---- | ---- | ---- | *13.70* | ---------- | ---- | ---- | *7.40* | ---------- | *7.40* | ---- | ---- | ---- |
| 6388 | ---- | ---- | 14.65 | ---------- | ---- | ---- | 4.78 | ---------- | 4.78 | ---- | ---- | ---- |
| ---- | ---- | ---- | *15.00* | ---------- | ---- | ---- | *4.50* | ---------- | *4.50* | ---- | ---- | ---- |
| 6389 | ---- | ---- | 7.65 | ---------- | ---- | ---- | 8.14 | ---------- | 8.14 | ---- | ---- | ---- |
| ---- | ---- | ---- | *7.02* | ---------- | ---- | ---- | *7.81* | ---------- | *7.81* | ---- | ---- | ---- |
| 6397 | ---- | ---- | 11.60 | ---------- | ---- | ---- | 7.57 | ---------- | 7.57 | ---- | ---- | ---- |
| ---- | ---- | ---- | *11.38* | ---------- | ---- | ---- | *7.90* | ---------- | *7.90* | ---- | ---- | ---- |
| 6425 | ---- | ---- | 8.35 | ---------- | ---- | ---- | 9.20 | ---------- | 9.20 | ---- | ---- | ---- |
| 6426 | ---- | ---- | 8.60 | ---------- | ---- | ---- | 9.28 | ---------- | 9.28 | ---- | ---- | ---- |
| ---- | ---- | ---- | *7.93* | ---------- | ---- | ---- | *9.02* | ---------- | *9.02* | ---- | ---- | ---- |
| 6427 | ---- | ---- | 4.50 | ---------- | ---- | ---- | 4.28 | ---------- | 4.28 | ---- | ---- | ---- |
| ---- | ---- | ---- | *4.34* | ---------- | ---- | ---- | *4.00* | ---------- | *4.00* | ---- | ---- | ---- |
| 6433 | ---- | ---- | 8.40 | ---------- | ---- | ---- | 8.76 | ---------- | 8.76 | ---- | ---- | ---- |
| ---- | ---- | ---- | *7.90* | ---------- | ---- | ---- | *9.00* | ---------- | *9.00* | ---- | ---- | ---- |
| 6441 | ---- | ---- | ---- | ---------- | ---- | ---- | 12.42 | ---------- | 12.42 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *12.37* | ---------- | *12.37* | ---- | ---- | ---- |
| 6482 | ---- | ---- | 11.95 | ---------- | ---- | ---- | 6.56 | ---------- | 6.56 | ---- | ---- | ---- |
| ---- | ---- | ---- | *11.57* | ---------- | ---- | ---- | *7.33* | ---------- | *7.33* | ---- | ---- | ---- |
| 6506 | ---- | ---- | 8.10 | ---------- | ---- | ---- | 8.06 | ---------- | 8.06 | ---- | ---- | ---- |
| ---- | ---- | ---- | *8.00* | ---------- | ---- | ---- | *8.00* | ---------- | *8.00* | ---- | ---- | ---- |
| 6541 | ---- | ---- | 8.25 | ---------- | ---- | ---- | 9.07 | ---------- | 9.07 | ---- | ---- | ---- |
| ---- | ---- | ---- | *7.90* | ---------- | ---- | ---- | *9.00* | ---------- | *9.00* | ---- | ---- | ---- |
| 6304 | ---- | ---- | 8.70 | ---------- | ---- | ---- | 8.46 | ---------- | 8.46 | ---- | ---- | ---- |
| 6305 | ---- | ---- | 14.95 | ---------- | ---- | ---- | 5.23 | ---------- | 5.23 | ---- | ---- | ---- |
| 6068 | ---- | ---- | 16.80 | ---------- | ---- | ---- | 2.55 | ---------- | 2.55 | 6.16 | 6.16 | 0.95 |
| ---- | ---- | ---- | *17.00* | *Bn, G, Super* | ---- | ---- | *2.00* | *Bl, Bn, G, T* | *2.00* | *5.00* | *5.00* | ---- |
| 6515 | ---- | ---- | 9.60 | ---------- | ---- | ---- | 8.22 | ---------- | 8.22 | ---- | ---- | ---- |
| ---- | ---- | ---- | *11.90* | ---------- | ---- | ---- | *6.57* | ---------- | *6.57* | ---- | ---- | ---- |
| 6421 | ---- | ---- | 12.80 | ---------- | ---- | ---- | 7.20 | ---------- | 7.20 | ---- | ---- | ---- |
| ---- | ---- | ---- | *13.00* | ---------- | ---- | ---- | *7.22* | ---------- | *7.22* | ---- | ---- | ---- |
| 6435 | ---- | ---- | 7.75 | ---------- | ---- | ---- | 9.22 | ---------- | 9.22 | ---- | ---- | ---- |
| ---- | ---- | ---- | *5.33* | ---------- | ---- | ---- | *10.22* | ---------- | *10.22* | ---- | ---- | ---- |

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **California Fertilizer Works, San Francisco, Cal.** | | |
| 6047 | Special | A. C. Denman & Sons, Redlands | 29.43 |
| | *Guaranteed* | | *30.70* |
| 6178 | Special Nursery Stock | A. C. Dungan, Exeter | 28.15 |
| | *Guaranteed* | | *27.80* |
| 6325* | Tankage | Stewart Cit. Assn., Upland | 41.41 |
| 6355* | Tankage | Stewart Cit. Assn., Upland | 41.76 |
| | *Guaranteed* | | *43.12* |
| 6354* | Tankage | Stewart Cit. Assn., Upland | 40.46 |
| | *Guaranteed* | | *39.61* |
| | **Cudahy Packing Co., Los Angeles, Cal.** | | |
| 6404 | Blood | I. W. Haskell et al., Azusa | 59.97 |
| | *Guaranteed* | | *60.50* |
| 6542 | Blood | J. H. Stewart, Redlands | ---- |
| | *Sold on Station Analysis.* | | |
| 6248* | Bone Meal Steamed | Geo. Wright, Azusa | ---- |
| | *Sold on Station Analysis.* | | |
| 6235 | Cudahy's Commercial Fertilizer | Jerome Reynolds, Covina | ---- |
| | *Sold on Station Analysis.* | | |
| 6444* | Cudahy's Mixed Fertilizer | R. M. Douglas, Covina | 32.24 |
| | *Guaranteed* | | *36.40* |
| 6402 | Cudahy's Special Lawn | Valley Supply Co., Glendale | 30.12 |
| | *Guaranteed* | | *32.00* |
| 6407* | Tankage No. 1 | Mrs. E. P. Hubbard, Azusa | 39.69 |
| 6446* | Tankage No. 1 | H. H. Church, Covina | 39.94 |
| 6511* | Tankage No. 1 | Mrs. O. F. Wright, Azusa | 40.14 |
| | *Guaranteed* | | *37.80* |
| 6408* | Tankage | S. S. Scofield et al., Azusa | 40.89 |
| 6529* | Tankage No. 2 | B. L. King, Covina | 45.28 |
| 6530* | Tankage No. 2 | B. L. King, Covina | 40.78 |
| | *Guaranteed* | | *40.60* |
| 6405* | Tankage | W. M. Warren, Covina | ---- |
| 6406* | Tankage | I. W. Haskell et al., Azusa | ---- |
| | *Sold on Station Analysis.* | | |

*6444—No statement of derivation. In violation of California Fertilizer Act.
*6325—85% fine.
*6355—86% fine.
*6354—84% fine.
*6248—71% fine.
*6407—78% fine.
*6446—78% fine.
*6511—73% fine.
*6408—76% fine.
*6529—76% fine.
*6530—76% fine.
*6405—79% fine.
*6406—78% fine.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6047 | ---- | ---- | 11.60 | ---------- | 1.61 | 0.48 | 2.31 | ---------- | 4.40 | 1.30 | 1.30 | 0.65 |
| ---- | ---- | ---- | *12.00* | *Bn* | *2.00* | | *2.50* | *Bl, Bn* | *4.50* | *1.50* | *1.50* | ---- |
| 6178 | 4.61 | 5.14 | 9.85 | ---------- | 1.94 | 0.58 | 1.48 | ---------- | 4.00 | 2.50 | 2.50 | 0.97 |
| ---- | *6.50* | *3.50* | *10.00* | *Bn, Super* | *2.00* | | *2.00* | *Bl, Bn* | *4.00* | *2.00* | *2.00* | ---- |
| 6325 | ---- | ---- | 9.00 | ---------- | ---- | ---- | 8.36 | ---------- | 8.36 | ---- | ---- | ---- |
| 6355 | ---- | ---- | 9.25 | ---------- | ---- | ---- | 8.40 | ---------- | 8.40 | ---- | ---- | ---- |
| ---- | ---- | ---- | *10.00* | ---------- | ---- | ---- | *8.60* | ---------- | *8.60* | ---- | ---- | ---- |
| 6354 | ---- | ---- | 8.90 | ---------- | ---- | ---- | 8.15 | ---------- | 8.15 | ---- | ---- | ---- |
| ---- | ---- | ---- | *9.30* | ---------- | ---- | ---- | 7.88 | ---------- | 7.88 | ---- | ---- | ---- |
| 6404 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.63 | ---------- | 13.63 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *13.75* | ---------- | *13.75* | ---- | ---- | ---- |
| 6542 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.51 | ---------- | 13.51 | ---- | ---- | ---- |
| 6248 | ---- | ---- | 20.70 | ---------- | ---- | ---- | 3.04 | ---------- | 3.04 | ---- | ---- | ---- |
| 6235 | ---- | ---- | 15.50 | ---------- | ---- | ---- | 2.31 | ---------- | 2.31 | ---- | 3.55 | 1.67 |
| 6444 | ---- | ---- | 9.50 | ---------- | ---- | ---- | 4.77 | ---------- | 4.77 | ---- | 1.83 | 2.07 |
| ---- | ---- | ---- | *8.00* | ---------- | ---- | ---- | *6.00* | ---------- | *6.00* | ---- | *2.00* | ---- |
| 6402 | ---- | ---- | 11.30 | ---------- | ---- | ---- | 4.75 | ---------- | 4.75 | ---- | 0.43 | 2.35 |
| ---- | ---- | ---- | *8.00* | ---------- | ---- | ---- | *4.00* | ---------- | *4.00* | ---- | *4.00* | ---- |
| 6407 | ---- | ---- | 9.00 | ---------- | ---- | ---- | 7.95 | ---------- | 7.95 | ---- | ---- | ---- |
| 6446 | ---- | ---- | 7.55 | ---------- | ---- | ---- | 8.25 | ---------- | 8.25 | ---- | ---- | ---- |
| 6511 | ---- | ---- | 7.00 | ---------- | ---- | ---- | 8.39 | ---------- | 8.39 | ---- | ---- | ---- |
| ---- | ---- | ---- | *6.00* | ---------- | ---- | ---- | *8.00* | ---------- | *8.00* | ---- | ---- | ---- |
| 6408 | ---- | ---- | 9.40 | ---------- | ---- | ---- | 8.17 | ---------- | 8.17 | ---- | ---- | ---- |
| 6529 | ---- | ---- | 6.30 | ---------- | ---- | ---- | 9.73 | ---------- | 9.73 | ---- | ---- | ---- |
| 6530 | ---- | ---- | 8.75 | ---------- | ---- | ---- | 8.25 | ---------- | 8.25 | ---- | ---- | ---- |
| ---- | ---- | ---- | *10.00* | ---------- | ---- | ---- | *8.00* | ---------- | *8.00* | ---- | ---- | ---- |
| 6405 | ---- | ---- | 6.90 | ---------- | ---- | ---- | 9.28 | ---------- | 9.28 | ---- | ---- | ---- |
| 6406 | ---- | ---- | 5.75 | ---------- | ---- | ---- | 9.75 | ---------- | 9.75 | ---- | ---- | ---- |

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Diamond Fertilizer Co., Los Angeles, Cal.** | | |
| 6051* | Garbage Tankage | W. H. Young, Duarte | ---- |
| | *Guaranteed* | | ---- |
| 6117* | Garbage Tankage | G. A. Hansen Fruit Co., Upland | ---- |
| | *Guaranteed* | | ---- |
| 6131* | Garbage Tankage | Henry Fuller, Bryn Mawr | ---- |
| 6147* | Garbage Tankage | Henry Fuller, Redlands | ---- |
| 6286* | Garbage Tankage | Oak Knoll Co., Pasadena | ---- |
| 6449* | Garbage Tankage | Robert Baird, Porterville | ---- |
| | *Guaranteed* | | ---- |
| 6052* | Garbage Tankage | A. B. Hill, Pomona | ---- |
| 6053* | Garbage Tankage | A. B. Hill, Pomona | ---- |
| 6067* | Garbage Tankage | L. A. Smith, Cucamonga | ---- |
| | *Sold on Station Analysis.* | | |
| | **Duff's Odorless Fertilizer Co., Glendale, Cal.** | | |
| 6395 | No. 1 | Manufacturer's Warehouse | 16.25 |
| | *Guaranteed* | | *19.10* |
| 6396 | No. 3 | Manufacturer's Warehouse | ---- |
| | *Guaranteed* | | ---- |
| 6514 | No. 3 | R. P. Kleinhaus, Malden, Wash | ---- |
| | *Guaranteed* | | ---- |
| | **General Fertilizer Association, San Bernardino, Cal.** | | |
| 6288 | Bat Guano | H. D. Derwin, Upland | 39.35 |
| | *Guaranteed* | | *44.73* |
| 6400 | Bat Guano | H. D. Derwin, Upland | ---- |
| | *Sold on Station Analysis.* | | |
| 6531* | Bone Meal | J. E. Schermerhorn, Highgrove | 38.44 |
| | *Guaranteed* | | *36.15* |
| 6493* | Fish Meal | J. A. Hall, Cucamonga | 46.11 |
| | *Guaranteed* | | *48.65* |
| 6491* | Garbage Tankage | D. R. Kilbourne, Cucamonga | ---- |
| 6492* | Garbage Tankage | W. E. Morse, Alta Loma | ---- |
| | *Guaranteed* | | ---- |
| 6071 | G. F. A. No. 2 | Factory at Ontario | 28.49 |
| | *Guaranteed* | | *28.80* |
| 6111 | G. F. A. Special No. 2 | J. H. Reynolds, Redlands | 28.05 |
| | *Guaranteed* | | *27.80* |
| 6321 | G. F. A. Special No. 2 | J. H. Reynolds, Redlands | 24.03 |
| | *Guaranteed* | | *29.80* |
| 6460 | G. F. A. Special No. 2 | F. F. Oster, Los Angeles | 23.13 |
| | *Guaranteed* | | *29.20* |

*6051—29% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6117—29% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6131—28% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6147—28% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6286—28% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6449—28% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6052—28% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6053—27% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6067—27% fine. In absence of market quotations no prices are given on Garbage Tankage.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6051 | ---- | ---- | 2.80 | -------- | ---- | ---- | 3.10 | -------- | 3.10 | ---- | 1.25 | ---- |
| ---- | ---- | ---- | *3.15* | -------- | ---- | ---- | *3.10* | -------- | *3.10* | ---- | *1.22* | ---- |
| 6117 | ---- | ---- | 3.10 | -------- | ---- | ---- | 3.17 | -------- | 3.17 | ---- | 1.07 | 1.20 |
| ---- | ---- | ---- | *4.00* | -------- | ---- | ---- | *3.30* | -------- | *3.30* | ---- | *1.25* | ---- |
| 6131 | ---- | ---- | 2.90 | -------- | ---- | ---- | 3.28 | -------- | 3.28 | ---- | 1.22 | 1.57 |
| 6147 | ---- | ---- | 2.85 | -------- | ---- | ---- | 3.37 | -------- | 3.37 | ---- | 1.02 | 1.25 |
| 6286 | ---- | ---- | 2.60 | -------- | ---- | ---- | 3.23 | -------- | 3.23 | ---- | 1.32 | 0.72 |
| 6449 | ---- | ---- | 2.65 | -------- | ---- | ---- | 3.51 | -------- | 3.51 | ---- | 1.52 | 1.32 |
| ---- | ---- | ---- | *3.00* | -------- | ---- | ---- | *3.00* | -------- | *3.00* | ---- | *1.00* | ---- |
| 6052 | ---- | ---- | 3.05 | -------- | ---- | ---- | 3.06 | -------- | 3.06 | ---- | 1.46 | ---- |
| 6053 | ---- | ---- | 3.05 | -------- | ---- | ---- | 3.10 | -------- | 3.10 | ---- | 1.23 | ---- |
| 6067 | ---- | ---- | 3.30 | -------- | ---- | ---- | *3.34* | -------- | *3.34* | ---- | *1.32* | ---- |
| 6395 | 4.52 | 1.08 | 5.60 | -------- | 1.12 | 0.72 | 0.93 | -------- | 2.77 | ---- | 0.71 | ---- |
| ---- | ---- | ---- | *5.00* | *Bn, G, Super* | ---- | ---- | ---- | *Bn, G* | *3.00* | ---- | *1.00* | ---- |
| 6396 | ---- | ---- | 2.90 | -------- | ---- | 0.78 | 1.21 | -------- | 1.99 | ---- | 1.17 | 0.57 |
| ---- | ---- | ---- | *1.00* | *G* | ---- | ---- | *1.00* | *G* | *1.00* | ---- | *1.00* | ---- |
| 6514 | ---- | ---- | 2.70 | -------- | ---- | 1.10 | 0.86 | -------- | 1.96 | ---- | 1.31 | 0.57 |
| ---- | ---- | ---- | *1.00* | *Bn, G* | ---- | ---- | ---- | *Bn, G* | *1.50* | ---- | *1.00* | ---- |
| 6288 | ---- | ---- | 4.40 | -------- | 2.17 | 1.66 | 5.05 | -------- | 8.88 | ---- | 0.96 | ---- |
| ---- | ---- | ---- | *4.48* | -------- | ---- | ---- | ---- | -------- | *9.00* | ---- | *1.45* | ---- |
| 6400 | ---- | ---- | 4.40 | -------- | 0.39 | 1.37 | 8.20 | -------- | 9.96 | ---- | 0.90 | ---- |
| 6531 | ---- | ---- | 26.10 | -------- | ---- | ---- | 3.56 | -------- | 3.56 | ---- | ---- | ---- |
| ---- | ---- | ---- | *25.00* | -------- | ---- | ---- | *3.25* | -------- | *3.25* | ---- | ---- | ---- |
| 6493 | ---- | ---- | 6.35 | -------- | ---- | ---- | 9.92 | -------- | 9.92 | ---- | ---- | ---- |
| ---- | ---- | ---- | *6.50* | -------- | ---- | ---- | *10.50* | -------- | *10.50* | ---- | ---- | ---- |
| 6491 | ---- | ---- | 2.35 | -------- | ---- | ---- | 3.07 | -------- | 3.07 | ---- | 1.23 | 1.35 |
| 6492 | ---- | ---- | 2.20 | -------- | ---- | ---- | 2.96 | -------- | 2.96 | ---- | 1.24 | 1.20 |
| ---- | ---- | ---- | *2.00* | -------- | ---- | ---- | *3.00* | -------- | *3.00* | ---- | *1.00* | ---- |
| 6071 | 6.03 | 3.82 | 9.85 | -------- | 1.79 | ---- | 2.18 | -------- | 3.97 | ---- | 2.37 | 1.25 |
| ---- | *8.00* | *2.00* | *10.00* | -------- | *1.50* | ---- | *2.62* | *Bl, Bn, G* | *4.12* | ---- | *2.00* | ---- |
| 6111 | 5.14 | 7.16 | 12.30 | -------- | 2.30 | ---- | 1.62 | -------- | 3.92 | ---- | 1.41 | 1.25 |
| ---- | *5.00* | *5.00* | *10.00* | *Bn, G* | *2.00* | ---- | *2.00* | *Bl, Bn, G* | *4.00* | ---- | *2.00* | ---- |
| 6321 | 2.93 | 6.32 | 9.25 | -------- | 1.70 | ---- | 1.62 | -------- | 3.32 | ---- | 1.73 | ---- |
| ---- | *5.00* | *5.00* | *10.00* | *Bn. G.* | *2.00* | ---- | *2.00* | *Bl, Bn, G* | *4.00* | ---- | *3.00* | ---- |
| 6460 | 4.02 | 4.48 | 8.50 | -------- | 1.69 | 0.42 | 1.46 | -------- | 3.57 | 1.30 | 1.30 | 0.77 |
| ---- | *5.00* | *3.00* | *8.00* | *Bn, G* | *2.00* | ---- | *3.00* | *Bl, Bn, G* | *5.00* | ---- | *1.50* | ---- |

*6531—51% fine.
*6493—68% fine.
*6491—33% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6492—36% fine. In absence of market quotations no prices are given on Garbage Tankage.

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **General Fertilizer Association—** Continued. | | |
| 6073 | G. F. A. No. 3 | Factory at Ontario | 26.79 |
| 6191 | G. F. A. No. 3 | G. F. Fish, Ontario | 28.16 |
| | *Guaranteed* | | *25.33* |
| 6072 | G. F. A. No. 5 | Factory at Ontario | 34.62 |
| | *Guaranteed* | | *34.30* |
| 6533 | G. F. A. No. 5 | Factory at Ontario | 33.08 |
| | *Guaranteed* | | *32.50* |
| 6322 | G. F. A. No. 5 Special | J. H. Reynolds, Redlands | 30.78 |
| | *Guaranteed* | | *32.00* |
| 6110 | Orange and Lemon No. 1 | J. H. Reynolds, Redlands | 34.32 |
| 6320 | Orange and Lemon No. 1 | J. H. Reynolds, Redlands | 29.17 |
| | *Guaranteed* | | *34.30* |
| 6070 | Special Lawn | Factory at Ontario | 33.73 |
| | *Guaranteed* | | *33.94* |
| 6532 | Special Mixed | L. R. Lee, Ontario | 33.90 |
| | *Guaranteed* | | *35.55* |
| | **Germain Seed and Plant Co., Los Angeles, Cal.** | | |
| 6362* | Nuvida Lawn and Garden | Manufacturer's Warehouse | 27.02 |
| 6401* | Nuvida Lawn and Garden | Valley Supply Co., Glendale | 28.55 |
| | *Guaranteed* | | *23.80* |
| | **Globe Grain and Milling Co., Los Angeles, Cal.** | | |
| 6361* | Garbage Tankage | Manufacturer's Warehouse | ---- |
| | *Guaranteed* | | ---- |
| | **Hauser Packing Company, Los Angeles, Cal.** | | |
| 6463 | Blood | Geo. W. Fuhr, Azusa | 59.31 |
| | *Guaranteed* | | *62.35* |
| 6489 | Blood | K. Lundeen, Los Angeles | 54.87 |
| | *Guaranteed* | | *52.80* |
| 6544 | Blood | E. N. Nahmens, Redlands | 62.88 |
| | *Guaranteed* | | *62.22* |
| 6080* | Bone Meal | Stewart Cit. Assn., Upland | 35.36 |
| 6081* | Bone Meal | Stewart Cit. Assn., Upland | 35.53 |
| 6082* | Bone Meal | Stewart Cit. Assn., Upland | 35.65 |
| 6132* | Bone Meal | Stewart Cit. Assn., Upland | 32.66 |
| 6150* | Bone Meal | Stewart Cit. Assn., Upland | 34.44 |
| 6151* | Bone Meal | Stewart Cit. Assn., Upland | 34.34 |
| | *Guaranteed* | | *32.55* |

*6362—Nitrogen given as nitric is guaranteed from cyanamid.
*6401—Nitrogen given as nitric is guaranteed from cyanamid.
*6361—31% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6080—71% fine.
*6081—69% fine.
*6082—67% fine.
*6132—65% fine.
*6150—71% fine.
*6151—73% fine.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6073 | 4.01 | 3.94 | 7.95 | ---------- | 1.29 | ---- | 1.02 | ---------- | 2.31 | ---- | 5.61 | 0.72 |
| 6191 | ---- | ---- | 10.75 | ---------- | ---- | ---- | 1.83 | ---------- | 1.83 | ---- | 5.40 | ---- |
| ---- | *6.00* | *4.00* | *10.00* | *Bn, G* | *0.60* | ---- | *1.05* | *Bl, Bn, G* | *1.65* | ---- | *5.00* | ---- |
| 6072 | ---- | ---- | 11.20 | ---------- | 1.66 | ---- | 3.56 | ---------- | 5.22 | ---- | 2.14 | 1.25 |
| ---- | ---- | ---- | *12.00* | *Bn, G, T* | *1.50* | ---- | *3.50* | *Bl, Bn, G* | *5.00* | ---- | *2.00* | ---- |
| 6533 | ---- | ---- | 10.55 | ---------- | 1.86 | ---- | 3.26 | ---------- | 5.12 | ---- | 1.97 | 0.57 |
| ---- | ---- | ---- | *10.00* | *Bn, G, T* | *1.50* | ---- | *3.50* | *Bl, Bn, G* | *5.00* | ---- | *2.00* | ---- |
| 6322 | 3.57 | 8.08 | 11.65 | ---------- | 2.56 | ---- | 2.00 | ---------- | 4.56 | ---- | 1.85 | 0.60 |
| ---- | *6.00* | *4.00* | *10.00* | *Bn, G* | *2.00* | ---- | *3.00* | *Bl, Bn, G* | *5.00* | ---- | *2.00* | ---- |
| 6110 | 6.44 | 3.46 | 9.90 | ---------- | 1.67 | ---- | 2.51 | ---------- | 4.18 | 4.76 | 4.76 | 1.00 |
| 6320 | 1.94 | 6.86 | 8.80 | ---------- | 2.00 | ---- | 2.05 | ---------- | 4.05 | 3.12 | 3.12 | 0.60 |
| ---- | *5.00* | *5.00* | *10.00* | *Bn, G, Super* | *1.50* | ---- | *2.50* | ---------- | *4.00* | *5.00* | *5.00* | ---- |
| 6070 | ---- | ---- | 6.85 | ---------- | 2.55 | ---- | 4.62 | ---------- | 7.17 | ---- | ---- | ---- |
| ---- | ---- | ---- | *7.00* | *Bn, G* | *2.60* | ---- | *4.60* | *Bl, Bn, G* | *7.20* | ---- | ---- | ---- |
| 6532 | ---- | ---- | 5.35 | ---------- | ---- | ---- | 7.18 | ---------- | 7.18 | ---- | 0.41 | ---- |
| ---- | ---- | ---- | *5.36* | *Bn, G* | ---- | ---- | *7.57* | *Bl, Bn, G* | *7.57* | ---- | *0.75* | ---- |
| 6362 | 8.17 | 2.08 | 10.25 | ---------- | ---- | ---- | ---- | ---------- | 4.81 | ---- | ---- | ---- |
| 6401 | 8.91 | 2.14 | 11.05 | ---------- | ---- | ---- | ---- | ---------- | 4.43 | ---- | ---- | ---- |
| ---- | *7.00* | *3.00* | *10.00* | ---------- | *2.00* | ---- | *2.00* | *Bl* | *4.00* | ---- | ---- | ---- |
| 6361 | ---- | ---- | 2.75 | ---------- | ---- | ---- | 3.58 | ---------- | 3.58 | ---- | 1.21 | 1.52 |
| ---- | ---- | ---- | *3.00* | ---------- | ---- | ---- | *3.00* | ---------- | *3.00* | ---- | *1.00* | ---- |
| 6463 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.48 | ---------- | 13.48 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *14.17* | ---------- | *14.17* | ---- | ---- | ---- |
| 6489 | ---- | ---- | ---- | ---------- | ---- | ---- | 12.47 | ---------- | 12.47 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *12.00* | ---------- | *12.00* | ---- | ---- | ---- |
| 6544 | ---- | ---- | ---- | ---------- | ---- | ---- | 14.29 | ---------- | 14.29 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *14.14* | ---------- | *14.14* | ---- | ---- | ---- |
| 6080 | ---- | ---- | 23.00 | ---------- | ---- | ---- | 3.49 | ---------- | 3.49 | ---- | ---- | ---- |
| 6081 | ---- | ---- | 23.00 | ---------- | ---- | ---- | 3.53 | ---------- | 3.53 | ---- | ---- | ---- |
| 6082 | ---- | ---- | 22.20 | ---------- | ---- | ---- | 3.73 | ---------- | 3.73 | ---- | ---- | ---- |
| 6132 | ---- | ---- | 20.10 | ---------- | ---- | ---- | 3.47 | ---------- | 3.47 | ---- | ---- | ---- |
| 6150 | ---- | ---- | 21.00 | ---------- | ---- | ---- | 3.70 | ---------- | 3.70 | ---- | ---- | ---- |
| 6151 | ---- | ---- | 21.40 | ---------- | ---- | ---- | 3.59 | ---------- | 3.59 | ---- | ---- | ---- |
| ---- | ---- | ---- | *21.00* | ---------- | ---- | ---- | *3.25* | ---------- | *3.25* | ---- | ---- | ---- |

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Hauser Packing Co.—** Continued. | | |
| 6209* | Bone Meal | Michael Rebhan, Covina | 37.00 |
| | *Guaranteed* | | *34.95* |
| 6293* | Bone Meal | W. M. Baird, Duarte | 22.57 |
| | *Guaranteed* | | *21.60* |
| 6525* | Garbage Tankage | Curtis Ranch Co., Bloomington | ---- |
| 6526* | Garbage Tankage | Curtis Ranch Co., Bloomington | ---- |
| | *Guaranteed* | | ---- |
| 6536 | Special | W. B. Glidden, Hollywood | 30.35 |
| | *Guaranteed* | | *29.80* |
| 6048* | Tankage | J. C. Wright, Azusa | 42.18 |
| 6373* | Tankage | J. C. Wright, Azusa | 40.58 |
| 6418* | Tankage | D. F. Bremner, Upland | 39.94 |
| 6423* | Tankage | A. B. Cowgill, Redlands | 39.67 |
| 6434* | Tankage | H. C. Meek, Upland | 39.03 |
| 6534* | Tankage | C. W. Rhodes, Pasadena | 39.66 |
| 6543* | Tankage | E. N. Nahmens, Redlands | 39.49 |
| | *Guaranteed* | | *39.20* |
| 6475* | Tankage | D. W. Divine, Highland | 40.68 |
| | *Guaranteed* | | *39.06* |
| 6370* | Tankage, Big Gun | E. D. Berry, Los Angeles | 44.64 |
| 6371* | Tankage, Big Gun | H. Damerel et al., Covina | 45.12 |
| 6372* | Tankage, Big Gun | Mrs. J. H. Simpson, Covina | 44.79 |
| 6384* | Tankage, Big Gun | E. E. Ebersale, Lordsburg | 45.35 |
| 6447* | Tankage | J. H. Simpson, Covina | 44.51 |
| 6495* | Tankage | G. N. Hamilton, Claremont | 43.38 |
| | *Guaranteed* | | *44.80* |
| 6090* | Tankage | Orange Hts. Ft. Grws. Assn., Corona | ---- |
| 6091* | Tankage | Corona Cit. Assn., Corona | ---- |
| | *Sold on Station Analysis.* | | |
| | **Hawaiian Fertilizer Co., Ltd., San Francisco, Cal.** | | |
| 6185* | Bone Meal | Lindsay Hay & Grain Co., Lindsay | 33.68 |
| | *Guaranteed* | | *32.70* |
| 6184* | Fish Guano | Lindsay Hay & Grain Co., Lindsay | 42.41 |
| | *Guaranteed* | | *38.85* |
| 6181 | Fruit and Vine A | Lindsay Hay & Grain Co., Lindsay | 41.75 |
| | *Guaranteed* | | *38.30* |
| 6187 | Fruit and Vine B | Lindsay Hay & Grain Co., Lindsay | 34.95 |
| | *Guaranteed* | | *29.30* |
| 6179 | Nitrate of Soda | Lindsay Hay & Grain Co., Lindsay | 49.86 |
| | *Guaranteed* | | *48.00* |
| 6180 | Nursery | Lindsay Hay & Grain Co., Lindsay | 35.82 |
| | *Guaranteed* | | *31.50* |

*6209—73% fine.
*6293—66% fine.
*6525—39% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6526—47% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6048—67% fine.
*6373—73% fine.
*6418—56% fine.
*6423—60% fine.
*6434—68% fine.
*6534—71% fine.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6209 | ---- | ---- | 23.10 | ---------- | ---- | ---- | 3.86 | ---------- | 3.86 | ---- | ---- | ---- |
| ---- | ---- | ---- | *22.50* | ---------- | ---- | ---- | *3.50* | ---------- | *3.50* | ---- | ---- | ---- |
| 6293 | ---- | ---- | 19.90 | ---------- | ---- | ---- | 1.11 | ---------- | 1.11 | ---- | ---- | ---- |
| ---- | ---- | ---- | *20.50* | ---------- | ---- | ---- | *0.75* | ---------- | *0.75* | ---- | ---- | ---- |
| 6525 | ---- | ---- | 2.85 | ---------- | ---- | ---- | 2.76 | ---------- | 2.76 | ---- | 1.08 | 1.25 |
| 6526 | ---- | ---- | 2.75 | ---------- | ---- | ---- | 2.40 | ---------- | 2.47 | ---- | 0.92 | 1.10 |
| ---- | ---- | ---- | *2.75* | ---------- | ---- | ---- | *3.00* | ---------- | *3.00* | ---- | *1.20* | ---- |
| 6536 | ---- | ---- | 9.65 | ---------- | ---- | ---- | 4.41 | ---------- | 4.41 | 1.57 | 1.57 | 0.97 |
| ---- | ---- | ---- | *10.00* | *Bn, T* | ---- | ---- | *4.00* | *Bl, Bn, T* | *4.00* | *2.00* | *2.00* | ---- |
| 6048 | ---- | ---- | 7.15 | ---------- | ---- | ---- | 8.85 | ---------- | 8.85 | ---- | ---- | ---- |
| 6373 | ---- | ---- | 7.75 | ---------- | ---- | ---- | 8.37 | ---------- | 8.37 | ---- | ---- | ---- |
| 6418 | ---- | ---- | 8.40 | ---------- | ---- | ---- | 8.11 | ---------- | 8.11 | ---- | ---- | ---- |
| 6423 | ---- | ---- | 8.55 | ---------- | ---- | ---- | 8.02 | ---------- | 8.02 | ---- | ---- | ---- |
| 6434 | ---- | ---- | 8.65 | ---------- | ---- | ---- | 7.85 | ---------- | 7.85 | ---- | ---- | ---- |
| 6534 | ---- | ---- | 8.05 | ---------- | ---- | ---- | 8.10 | ---------- | 8.10 | ---- | ---- | ---- |
| 6543 | ---- | ---- | 8.65 | ---------- | ---- | ---- | 7.96 | ---------- | 7.96 | ---- | ---- | ---- |
| ---- | ---- | ---- | *8.00* | ---------- | ---- | ---- | *8.00* | ---------- | *8.00* | ---- | ---- | ---- |
| 6475 | ---- | ---- | 12.75 | ---------- | ---- | ---- | 7.56 | ---------- | 7.56 | ---- | ---- | ---- |
| ---- | ---- | ---- | *11.40* | ---------- | ---- | ---- | *7.40* | ---------- | *7.40* | ---- | ---- | ---- |
| 6370 | ---- | ---- | 5.15 | ---------- | ---- | ---- | 9.77 | ---------- | 9.77 | ---- | ---- | ---- |
| 6371 | ---- | ---- | 4.10 | ---------- | ---- | ---- | 10.06 | ---------- | 10.06 | ---- | ---- | ---- |
| 6372 | ---- | ---- | 4.40 | ---------- | ---- | ---- | 9.93 | ---------- | 9.93 | ---- | ---- | ---- |
| 6384 | ---- | ---- | 4.90 | ---------- | ---- | ---- | 9.98 | ---------- | 9.98 | ---- | ---- | ---- |
| 6447 | ---- | ---- | 4.85 | ---------- | ---- | ---- | 9.79 | ---------- | 9.79 | ---- | ---- | ---- |
| 6495 | ---- | ---- | 5.75 | ---------- | ---- | ---- | 9.37 | ---------- | 9.37 | ---- | ---- | ---- |
| ---- | ---- | ---- | *4.00* | ---------- | ---- | ---- | *10.00* | ---------- | *10.00* | ---- | ---- | ---- |
| 6090 | ---- | ---- | 8.85 | ---------- | ---- | ---- | 7.40 | ---------- | 7.40 | ---- | ---- | ---- |
| 6091 | ---- | ---- | 8.35 | ---------- | ---- | ---- | 7.57 | ---------- | 7.57 | ---- | ---- | ---- |
| 6185 | ---- | ---- | 19.60 | ---------- | ---- | ---- | 3.82 | ---------- | 3.82 | ---- | ---- | ---- |
| ---- | ---- | ---- | *20.00* | ---------- | ---- | ---- | *3.50* | ---------- | *3.50* | ---- | ---- | ---- |
| 6184 | ---- | ---- | 7.85 | ---------- | ---- | ---- | 8.79 | ---------- | 8.79 | ---- | ---- | ---- |
| ---- | ---- | ---- | *7.50* | ---------- | ---- | ---- | *8.00* | ---------- | *8.00* | ---- | ---- | ---- |
| 6181 | 9.13 | 1.22 | 10.35 | ---------- | 1.06 | 2.12 | 0.97 | ---------- | 4.15 | 9.09 | 9.09 | 0.90 |
| ---- | *7.50* | *1.50* | *9.00* | *Bn, Super, T* | *1.00* | *1.50* | *1.00* | *Bl, Bn, G, T* | *3.50* | *9.00* | *9.00* | ---- |
| 6187 | 10.30 | 1.20 | 11.50 | ---------- | 1.11 | 2.05 | 1.04 | ---------- | 4.20 | 5.06 | 5.06 | 0.55 |
| ---- | *7.50* | *1.50* | *9.00* | *Bn, Super, T* | *1.00* | *1.50* | *1.00* | *Bl, Bn, G, T* | *3.50* | *4.50* | *4.50* | ---- |
| 6179 | ---- | ---- | ---- | ---------- | 15.58 | ---- | ---- | ---------- | 15.58 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | *15.00* | ---- | ---- | ---------- | *15.00* | ---- | ---- | ---- |
| 6180 | 6.86 | 2.84 | 9.70 | ---------- | 1.08 | 2.33 | 2.79 | ---------- | 6.20 | 2.23 | 2.23 | 0.60 |
| ---- | *5.00* | *2.00* | *7.00* | *Bn, Super, T* | *1.00* | *2.00* | *3.00* | *Bl, Bn, G, T* | *6.00* | *1.50* | *1.50* | ---- |

*6543—60% fine.
*6475—73% fine.
*6370—56% fine.
*6371—77% fine.
*6372—75% fine.
*6384—66% fine.
*6447—63% fine.
*6495—65% fine.
*6090—64% fine.
*6091—71% fine.
*6185—69% fine.
*6184—63% fine.

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Hawaiian Fertilizer Co.—** Continued. | | |
| 6183 | Rape Seed Meal | Lindsay Hay & Grain Co., Lindsay | ---- |
| | *Guaranteed* | | ---- |
| 6182 | Special Fall | Lindsay Hay & Grain Co., Lindsay | 30.39 |
| | *Guaranteed* | | *26.58* |
| 6165 | Superphosphate | Johnson Bros. & Co., Turlock | 17.45 |
| | *Guaranteed* | | *15.98* |
| 6186* | Tankage | Lindsay Hay & Grain Co., Lindsay | 34.77 |
| | *Guaranteed* | | *33.60* |
| | **Los Angeles Fertilizer Co., Los Angeles, Cal.** | | |
| 6271 | Bat Guano | C. C. Chapman, Fullerton | ---- |
| | *Sold on Station Analysis.* | | |
| 6399* | Tankage | A. L. Wright, Jr., Los Angeles | 27.77 |
| | *Guaranteed* | | *29.40* |
| | **Mountain Copper Company, San Francisco, Cal.** | | |
| 6163 | Superphosphate | The Grange Co., Turlock | 17.84 |
| | *Guaranteed* | | *16.83* |
| 6454 | Superphosphate | Chas. H. Low, Riverside | 16.51 |
| | *Guaranteed* | | *16.45* |
| 6156 | 3-10-2 | Union Com. Co., Santa Barbara | 22.89 |
| | *Guaranteed* | | *23.83* |
| | **Nitrate Agencies Company, Los Angeles, Cal.** | | |
| 6154 | Nitrate of Soda | Sparr Fruit Co., Fillmore | 48.67 |
| 6158 | Nitrate of Soda | H. Booksin, San Jose | 48.67 |
| | *Guaranteed* | | *48.00* |
| | **Oakland Meat & Packing Co., Oakland, Cal.** | | |
| 6387* | Whale Tankage | Alta Cresta Rancho, Riverside | 49.60 |
| 6436* | Whale Tankage | M. C. Mascart, Redlands | 51.74 |
| | *Guaranteed* | | *50.40* |

*6186—85% fine.
*6399—61% fine.
*6387—88% fine.
*6436—85% fine.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6183 | ---- | ---- | 2.40 | ---- | ---- | ---- | 4.77 | ---- | 4.77 | ---- | 1.07 | ---- |
| ---- | ---- | ---- | *2.00* | ---- | ---- | ---- | *5.00* | ---- | *5.00* | ---- | *1.00* | ---- |
| 6182 | 11.84 | 0.16 | 12.00 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 9.63 | 1.25 |
| ---- | *7.00* | *5.00* | *12.00* | *Phosphates* | ---- | ---- | ---- | ---- | ---- | *10.00* | *10.00* | ---- |
| 6165 | 18.56 | 0.44 | 19.00 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| ---- | *17.00* | *1.00* | *18.00* | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 6186 | ---- | ---- | 15.05 | ---- | ---- | ---- | 5.77 | ---- | 5.77 | ---- | ---- | ---- |
| ---- | ---- | ---- | *15.00* | ---- | ---- | ---- | *5.50* | ---- | *5.50* | ---- | ---- | ---- |
| 6271 | ---- | ---- | 6.65 | ---- | 0.57 | 1.80 | 5.25 | ---- | 7.62 | ---- | 1.91 | ---- |
| 6399 | ---- | ---- | 13.15 | ---- | ---- | ---- | 4.42 | ---- | 4.42 | ---- | ---- | ---- |
| ---- | ---- | ---- | *15.00* | ---- | ---- | ---- | *4.50* | ---- | *4.50* | ---- | ---- | ---- |
| 6163 | 18.98 | 0.22 | 19.20 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| ---- | *17.90* | *0.30* | *18.20* | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 6454 | 17.56 | 0.34 | 17.90 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| ---- | *17.50* | *0.50* | *18.00* | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 6156 | 9.84 | 0.36 | 10.20 | ---- | 1.67 | ---- | 1.21 | ---- | 2.88 | ---- | 1.64 | 1.22 |
| ---- | *10.00* | *0.25* | *10.25* | *Phosphate of Lime* | *2.00* | ---- | *1.00* | *Bl* | *3.00* | *2.00* | *2.00* | ---- |
| 6154 | ---- | ---- | ---- | ---- | 15.21 | ---- | ---- | ---- | 15.21 | ---- | ---- | ---- |
| 6158 | ---- | ---- | ---- | ---- | 15.21 | ---- | ---- | ---- | 15.21 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---- | *15.00* | ---- | ---- | ---- | *15.00* | ---- | ---- | ---- |
| 6387 | ---- | ---- | ---- | ---- | ---- | ---- | 11.81 | ---- | 11.81 | ---- | ---- | ---- |
| 6436 | ---- | ---- | 1.10 | ---- | ---- | ---- | 12.32 | ---- | 12.32 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---- | ---- | ---- | *12.00* | ---- | *12.00* | ---- | ---- | ---- |

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| **Pacific Bone, Coal and Fertilizing Co., San Francisco, Cal.** | | | |
| 6062 | Blood | California Portland Cem't Co., Colton | 61.78 |
| | *Guaranteed* | | *61.38* |
| 6300 | Blood | Dr. C. S. Lombard, Redlands | 61.47 |
| | *Guaranteed* | | *61.78* |
| 6063 | Blood | A. F. Call Estate, Corona | ---- |
| | *Sold on Station Analysis.* | | |
| 6149* | Bone Meal, Steamed | Orange Hts. Fruit Assn., Corona | 35.21 |
| 6223* | Bone Meal, Steamed | W. A. Strong et al., Los Angeles | 35.71 |
| 6328* | Bone Meal, Steamed | Call Lemon Assn., Corona | 34.89 |
| 6333* | Bone Meal, Steamed | Rialto Orange Co., Rialto | 34.78 |
| | *Guaranteed* | | *34.20* |
| 6188 | Citrona No. 1 | Basil Pryor, Lindsay | 34.69 |
| | *Guaranteed* | | *34.10* |
| 6189 | Lupine | Basil Pryor, Lindsay | 27.82 |
| | *Guaranteed* | | *28.46* |
| 6332 | Nitrate of Soda | Rialto Orange Co., Rialto | 49.12 |
| | *Guaranteed* | | *48.00* |
| 6331* | Nitrolim Manure | Rialto Orange Co., Rialto | 58.56 |
| | *Guaranteed* | | *57.60* |
| 6374* | Tankage | San Jacinto Land Co., Arlington | 45.38 |
| 6375* | Tankage | San Jacinto Land Co., Arlington | 46.41 |
| 6516* | Tankage | Orange Hts. Fruit Assn., Corona | 40.24 |
| | *Guaranteed* | | *45.35* |
| 6422* | Tankage | W. C. Nickerson, Redlands | 34.84 |
| | *Guaranteed* | | *34.30* |
| 6461* | Tankage | So. Cal State Hospital, Patton | 34.57 |
| | *Guaranteed* | | *35.70* |
| 6485* | Tankage | C. E. McLaughlin, Rialto | 40.22 |
| | *Guaranteed* | | *40.60* |
| **Pacific Coast Beef and Provision Co., Los Angeles, Cal.** | | | |
| 6431* | Tankage | Geo. H. Cheesman, Walnut | 37.59 |
| | *Guaranteed* | | *29.05* |
| **Pacific Guano and Fertilizer Co., San Francisco, Cal.** | | | |
| 6411 | Blood | E. L. Seymour, Highland | 58.04 |
| | *Guaranteed* | | *57.86* |
| 6523 | Blood | Lorbeer Bros., Pomona | 61.42 |
| | *Guaranteed* | | *61.07* |
| 6195* | Bone Meal | D. Ostendorf, Lindsay | 38.29 |
| | *Guaranteed* | | *35.34* |
| 6334* | Bone Meal, Steamed | T. J. Dofflemeyer & Sons, Exeter | 36.93 |
| | *Guaranteed* | | *36.45* |

*6149—60% fine.
*6223—58% fine.
*6328—70% fine.
*6333—65% fine.
*6331—Nitrogen derived from cyanamid.
*6374—80% fine. Contains hoof.
*6375—74% fine. Contains hoof.
*6516—75% fine.
*6422—81% fine.
*6461—70% fine.
*6485—83% fine.
*6431—75% fine.
*6195—56% fine.
*6334—71% fine.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6062 | ---- | ---- | ---- | ---------- | ---- | ---- | 14.04 | ---------- | 14.04 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *13.95* | ---------- | *13.95* | ---- | ---- | ---- |
| 6300 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.97 | ---------- | 13.97 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *14.04* | ---------- | *14.04* | ---- | ---- | ---- |
| 6063 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.81 | ---------- | 13.81 | ---- | ---- | ---- |
| 6149 | ---- | ---- | 23.40 | ---------- | ---- | ---- | 3.37 | ---------- | 3.37 | ---- | ---- | ---- |
| 6223 | ---- | ---- | 23.90 | ---------- | ---- | ---- | 3.38 | ---------- | 3.38 | ---- | ---- | ---- |
| 6328 | ---- | ---- | 24.30 | ---------- | ---- | ---- | 3.10 | ---------- | 3.10 | ---- | ---- | ---- |
| 6333 | ---- | ---- | 23.80 | ---------- | ---- | ---- | 3.18 | ---------- | 3.18 | ---- | ---- | ---- |
| ---- | ---- | ---- | *24.00* | ---------- | ---- | ---- | *3.00* | ---------- | *3.00* | ---- | ---- | ---- |
| 6188 | 7.41 | 3.64 | 11.05 | ---------- | 1.54 | ---- | 1.39 | ---------- | 2.93 | 6.99 | 6.99 | 0.60 |
| ---- | *7.00* | *3.00* | *10.00* | *Bn, Super* | *1.50* | ---- | *1.50* | *Bl, Bn, T* | *3.00* | *7.00* | *7.00* | ---- |
| 6189 | 8.47 | 1.08 | 9.55 | ---------- | ---- | ---- | ---- | ---------- | ---- | 9.93 | 9.93 | 0.65 |
| ---- | *9.00* | *1.00* | *10.00* | *Super* | ---- | ---- | ---- | ---------- | ---- | *10.00* | *10.00* | ---- |
| 6332 | ---- | ---- | ---- | ---------- | 15.35 | ---- | ---- | ---------- | 15.35 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | *15.00* | ---- | ---- | ---------- | *15.00* | ---- | ---- | ---- |
| 6331 | ---- | ---- | ---- | ---------- | ---- | ---- | ---- | ---------- | 18.30 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | ---- | ---------- | 18.00 | ---- | ---- | ---- |
| 6374 | ---- | ---- | 4.35 | ---------- | ---- | ---- | 10.08 | ---------- | 10.08 | ---- | ---- | ---- |
| 6375 | ---- | ---- | 5.70 | ---------- | ---- | ---- | 10.10 | ---------- | 10.10 | ---- | ---- | ---- |
| 6516 | ---- | ---- | 5.10 | ---------- | ---- | ---- | 8.73 | ---------- | 8.73 | ---- | ---- | ---- |
| ---- | ---- | ---- | *5.50* | ---------- | ---- | ---- | *9.88* | ---------- | *9.88* | ---- | ---- | ---- |
| 6422 | ---- | ---- | 13.05 | ---------- | ---- | ---- | 6.12 | ---------- | 6.12 | ---- | ---- | ---- |
| ---- | ---- | ---- | *13.00* | ---------- | ---- | ---- | *6.00* | ---------- | *6.00* | ---- | ---- | ---- |
| 6461 | ---- | ---- | 3.25 | ---------- | ---- | ---- | 7.69 | ---------- | 7.69 | ---- | ---- | ---- |
| ---- | ---- | ---- | *3.00* | ---------- | ---- | ---- | *8.00* | ---------- | *8.00* | ---- | ---- | ---- |
| 6485 | ---- | ---- | 9.10 | ---------- | ---- | ---- | 8.06 | ---------- | 8.06 | ---- | ---- | ---- |
| ---- | ---- | ---- | *10.00* | ---------- | ---- | ---- | *8.00* | ---------- | *8.00* | ---- | ---- | ---- |
| 6431 | ---- | ---- | 9.30 | ---------- | ---- | ---- | 7.40 | ---------- | 7.40 | ---- | ---- | ---- |
| ---- | ---- | ---- | *8.50* | ---------- | ---- | ---- | *5.50* | ---------- | *5.50* | ---- | ---- | ---- |
| 6411 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.19 | ---------- | 13.19 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *13.15* | ---------- | *13.15* | ---- | ---- | ---- |
| 6523 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.96 | ---------- | 13.96 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *13.88* | ---------- | *13.88* | ---- | ---- | ---- |
| 6195 | ---- | ---- | 22.90 | ---------- | ---- | ---- | 4.21 | ---------- | 4.21 | ---- | ---- | ---- |
| ---- | ---- | ---- | *22.00* | ---------- | ---- | ---- | *3.70* | ---------- | *3.70* | ---- | ---- | ---- |
| 6334 | ---- | ---- | 23.30 | ---------- | ---- | ---- | 3.80 | ---------- | 3.80 | ---- | ---- | ---- |
| ---- | ---- | ---- | *23.00* | ---------- | ---- | ---- | *3.75* | ---------- | *3.75* | ---- | ---- | ---- |

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Pacific Guano and Fertilizer Co.—** Continued. | | |
| 6193 | Diamond F and V | D. Ostendorf, Lindsay | 35.29 |
| 6197 | Diamond F and V | F. Ostendorf, Lindsay | 35.34 |
| | *Guaranteed* | | *33.00* |
| 6194 | Diamond N | D. Ostendorf, Lindsay | 31.52 |
| | *Guaranteed* | | *27.90* |
| 6196 | Diamond PP | D. Ostendorf, Lindsay | 29.56 |
| | *Guaranteed* | | *29.28* |
| 6192 | Nitrate of Soda | D. Ostendorf, Lindsay | 48.96 |
| | *Guaranteed* | | *48.00* |
| 6123 | O.K. | T. Miyazaki, San Juan | 42.42 |
| | *Guaranteed* | | *45.20* |
| 6412 | Special | A. C. Moll, San Bernardino | 24.62 |
| 6524 | Special | E. F. Struve, Pomona | 25.06 |
| | *Guaranteed* | | *24.75* |
| 6416 | Special | Hugh Latimer, Arlington | 26.80 |
| 6488 | Special | Hugh Latimer, Arlington | 26.92 |
| | *Guaranteed* | | *26.85* |
| 6547 | Special | E. E. Cole, Redlands | 24.72 |
| | *Guaranteed* | | *23.90* |
| 6162 | Superphosphate Gaviota Cresco | T. E. Wilson, Ceres | 17.71 |
| 6267 | Superphosphate Cresco | Smith & Miner, Santa Ana | 17.17 |
| 6443 | Superphosphate Cresco | P. B. Goethals, Arlington | 16.07 |
| | *Guaranteed* | | *15.98* |
| 6410* | Tankage | D. W. Divine, Highland | 34.06 |
| | *Guaranteed* | | *33.08* |
| 6424* | Tankage | J. D. Boley et al., Highland | 33.95 |
| | *Guaranteed* | | *32.94* |
| 6484* | Tankage | C. E. McLaughlin, Rialto | 41.45 |
| | *Guaranteed* | | *41.67* |
| | **Pacific Reduction Co., Los Angeles, Cal.** | | |
| 6409* | Organic Tankage | W. M. Warren, Covina | ---- |
| 6445* | Organic Tankage | M. T. Durrell, Azusa | ---- |
| 6497* | Organic Tankage | W. M. Baird, Duarte | ---- |
| 6507* | Organic Tankage | W. M. Baird, Duarte | ---- |
| 6509* | Organic Tankage | Chas. H. Low, Riverside | ---- |
| 6522* | Organic Tankage | S. M. L. Cit. Assn., Lamanda Park | ---- |
| 6535* | Organic Tankage | Curtis Ranch Co., Bloomington | ---- |
| | *Guaranteed* | | |

*6410—83% fine.
*6424—93% fine.
*6484—79% fine.
*6409—32% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6445—37% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6497—31% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6507—36% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6509—34% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6522—41% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6535—41% fine. In absence of market quotations no prices are given on Garbage Tankage.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6193 | 8.80 | 2.30 | 11.10 | ---------- | 0.62 | ---- | 2.10 | ---------- | 2.72 | 7.25 | 7.25 | 0.67 |
| 6197 | 8.68 | 1.92 | 10.60 | ---------- | 0.59 | ---- | 2.24 | ---------- | 2.83 | 7.25 | 7.25 | 0.52 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *0.50* | ---- | *2.00* | *Bl, Bn, T, Fs, G* | *2.50* | *7.00* | *7.00* | ---- |
| 6194 | 8.89 | 1.26 | 10.15 | ---------- | 0.96 | ---- | 3.47 | ---------- | 4.43 | 2.37 | 2.37 | ---- |
| ---- | *8.00* | *1.00* | *9.00* | *Bn, Super* | *1.00* | ---- | *3.00* | *Bl, Bn, Fs* | *4.00* | *2.00* | *2.00* | ---- |
| 6196 | 12.40 | 0.80 | 13.20 | ---------- | ---- | ---- | ---- | ---------- | ---- | 8.95 | 8.95 | 0.70 |
| ---- | *12.00* | *1.00* | *13.00* | *Super* | ---- | ---- | ---- | ---------- | ---- | *9.00* | *9.00* | ---- |
| 6192 | ---- | ---- | ---- | ---------- | 15.30 | ---- | ---- | ---------- | 15.30 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | *15.00* | ---- | ---- | ---------- | *15.00* | ---- | ---- | ---- |
| 6123 | 7.30 | 0.60 | 7.90 | ---------- | 2.52 | ---- | 2.05 | ---------- | 4.57 | 9.32 | 9.32 | 0.82 |
| ---- | *7.00* | *1.00* | *8.00* | *Bn, Super, G* | *3.00* | ---- | *2.00* | *Bl, Bn, G, T* | *5.00* | *10.00* | *10.00* | ---- |
| 6412 | ---- | ---- | 10.60 | ---------- | 1.66 | ---- | 2.83 | ---------- | 4.49 | ---- | 0.54 | 0.95 |
| 6524 | ---- | ---- | 10.65 | ---------- | 1.46 | ---- | 3.08 | ---------- | 4.54 | ---- | 0.58 | 1.07 |
| ---- | ---- | ---- | *10.50* | *Bn, Super* | *1.50* | ---- | *3.00* | *Bn, T* | *4.50* | *0.50* | *0.50* | ---- |
| 6416 | ---- | ---- | 10.75 | ---------- | 1.27 | ---- | 3.11 | ---------- | 4.38 | ---- | 0.85 | 0.97 |
| 6488 | ---- | ---- | 10.85 | ---------- | 1.62 | ---- | 2.85 | ---------- | 4.47 | ---- | 0.79 | 1.00 |
| ---- | ---- | ---- | *10.50* | *Bn, Super* | *1.50* | ---- | *3.00* | *Bn, T* | *4.50* | *0.50* | *0.50* | ---- |
| 6547 | 7.17 | 0.78 | 7.95 | ---------- | 1.27 | 0.30 | 1.48 | ---------- | 3.05 | ---- | 3.16 | 1.60 |
| ---- | *7.00* | ---- | *7.00* | *G, Super* | *1.00* | ---- | *2.00* | *G, T* | *3.00* | *3.00* | *3.00* | ---- |
| 6162 | 18.84 | 0.36 | 19.20 | ---------- | ---- | ---- | ---- | ---------- | ---- | ---- | ---- | ---- |
| 6267 | 18.28 | 0.22 | 18.50 | ---------- | ---- | ---- | ---- | ---------- | ---- | ---- | ---- | ---- |
| 6443 | 17.10 | 0.60 | 17.70 | ---------- | ---- | ---- | ---- | ---------- | ---- | ---- | ---- | ---- |
| ---- | *17.00* | *1.00* | *18.00* | ---------- | ---- | ---- | ---- | ---------- | ---- | ---- | ---- | ---- |
| 6410 | ---- | ---- | 16.55 | ---------- | ---- | ---- | 5.35 | ---------- | 5.35 | ---- | ---- | ---- |
| ---- | ---- | ---- | *15.75* | ---------- | ---- | ---- | *5.25* | ---------- | *5.25* | ---- | ---- | ---- |
| 6424 | ---- | ---- | 20.30 | ---------- | ---- | ---- | 4.70 | ---------- | 4.70 | ---- | ---- | ---- |
| ---- | ---- | ---- | *19.75* | ---------- | ---- | ---- | *4.55* | ---------- | *4.55* | ---- | ---- | ---- |
| 6484 | ---- | ---- | 9.00 | ---------- | ---- | ---- | 8.37 | ---------- | 8.37 | ---- | ---- | ---- |
| ---- | ---- | ---- | *8.95* | ---------- | ---- | ---- | *8.43* | ---------- | *8.43* | ---- | ---- | ---- |
| 6409 | ---- | ---- | 2.65 | ---------- | ---- | ---- | 3.07 | ---------- | 3.07 | ---- | 1.23 | 1.27 |
| 6445 | ---- | ---- | 3.00 | ---------- | ---- | ---- | 3.10 | ---------- | 3.10 | ---- | 1.18 | 1.17 |
| 6497 | ---- | ---- | 2.45 | ---------- | ---- | ---- | 3.05 | ---------- | 3.05 | ---- | 1.52 | 1.35 |
| 6507 | ---- | ---- | 2.25 | ---------- | ---- | ---- | 2.88 | ---------- | 2.88 | ---- | 1.26 | 1.40 |
| 6509 | ---- | ---- | 2.15 | ---------- | ---- | ---- | 2.68 | ---------- | 2.68 | ---- | 1.27 | 1.20 |
| 6522 | ---- | ---- | 2.25 | ---------- | ---- | ---- | 3.17 | ---------- | 3.17 | ---- | 1.24 | 1.45 |
| 6535 | ---- | ---- | 2.10 | ---------- | ---- | ---- | 2.92 | ---------- | 2.92 | ---- | 1.36 | 1.37 |
| ---- | ---- | ---- | *2.75* | ---------- | ---- | ---- | *3.00* | ---------- | *3.00* | ---- | *1.25* | ---- |

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Redlands Fruit Association, Redlands, Cal.** | | |
| 6050 | Dried Blood | Elmer Hayward, Orange | 60.37 |
| | *Guaranteed* | | *58.08* |
| | **Swift & Company, Chicago, Ill.** | | |
| 6088* | Tankage | B. L. Byer, Upland | 32.75 |
| | *Guaranteed* | | *32.20* |
| | **Union Fertilizer Co., Los Angeles, Cal.** | | |
| 6065 | Fruiting | H. C. Lash, Rialto | 26.40 |
| 6089 | Fruiting | E. G. Generent, Corona | 25.84 |
| 6128 | Fruiting | E. E. Cole, Redlands | 26.05 |
| 6133 | Fruiting | H. O. Blohm, Upland | 25.89 |
| 6323 | Fruiting | E. E. Cole, Redlands | 27.76 |
| 6363 | Fruiting | F. Bebermeyer, Orange | 25.83 |
| 6390 | Fruiting | Geo. R. Tyler, Pomona | 27.43 |
| 6415 | Fruiting | H. C. Lash, Rialto | 29.03 |
| | *Guaranteed* | | *24.90* |
| 6066 | Nursery | H. C. Lash, Rialto | 31.41 |
| 6127 | Nursery | E. E. Cole, Redlands | 29.61 |
| 6324 | Nursery | E. E. Cole, Redlands | 29.82 |
| 6391 | Nursery | Geo. R. Tyler, Pomona | 32.28 |
| | *Guaranteed* | | *28.75* |
| 6496* | Rock Phosphate | Wright Bros., Riverside | ---- |
| | *Guaranteed* | | ---- |
| | **Union Superphosphate Co., San Francisco, Cal.** | | |
| 6153 | Superphosphate | Sparr Fruit Co., Fillmore | 17.38 |
| | *Guaranteed* | | *15.98* |
| | **Western Fertilizer Co., San Francisco, Cal.** | | |
| 6230* | Wizard | Nance & Tater, Porterville | 33.12 |
| 6283* | Wizard | Riverside Milling Co., Riverside | 36.76 |
| | *Guaranteed* | | *44.40* |
| 6252* | Wizard | C. H. Nearpass, San Diego | 38.58 |
| | *Guaranteed* | | *43.30* |

*6088—58% fine.
*6496—36% fine. Through 100 mesh sieve.
*6230—No statement of derivation. In violation of the California Fertilizer Act.
*6283—No statement of derivation. In violation of the California Fertilizer Act.
*6252—No statement of derivation. In violation of the California Fertilizer Act.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6050 | ---- | ---- | ---- | -------- | ---- | ---- | 13.72 | -------- | 13.72 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | -------- | ---- | ---- | *13.20* | -------- | *13.20* | ---- | ---- | ---- |
| 6088 | ---- | ---- | 24.10 | -------- | ---- | ---- | 3.78 | -------- | 3.78 | ---- | ---- | ---- |
| ---- | ---- | ---- | *22.00* | -------- | ---- | ---- | *4.00* | -------- | *4.00* | ---- | ---- | ---- |
| 6065 | 7.23 | 1.32 | 8.55 | -------- | 1.27 | ---- | 1.89 | -------- | 3.16 | ---- | 3.35 | 0.95 |
| 6089 | 6.77 | 1.58 | 8.35 | -------- | 0.37 | 0.90 | 1.88 | -------- | 3.15 | ---- | 3.18 | 0.90 |
| 6128 | 6.36 | 1.14 | 7.50 | -------- | 0.83 | 0.38 | 2.05 | -------- | 3.26 | ---- | 3.41 | 0.77 |
| 6133 | 6.99 | 0.96 | 7.95 | -------- | 1.33 | ---- | 1.89 | -------- | 3.22 | ---- | 3.27 | 1.10 |
| 6323 | 6.02 | 2.68 | 8.70 | -------- | 1.23 | ---- | 2.26 | -------- | 3.49 | ---- | 3.25 | 0.92 |
| 6363 | 6.10 | 2.30 | 8.40 | -------- | 1.07 | ---- | 2.01 | -------- | 3.08 | ---- | 3.20 | 0.60 |
| 6390 | 6.25 | 2.60 | 8.85 | -------- | 1.10 | ---- | 2.24 | -------- | 3.34 | ---- | 3.27 | 0.55 |
| 6415 | 6.75 | 2.70 | 9.45 | -------- | 0.39 | 0.93 | 2.31 | -------- | 3.63 | ---- | 3.30 | 1.00 |
| ---- | *7.00* | *1.50* | *8.50* | *Bn, Super, G, T* | *0.75* | *0.60* | *1.65* | *Bn, G, T* | *3.00* | ---- | *3.00* | ---- |
| 6066 | 6.58 | 0.72 | 7.30 | -------- | 1.71 | ---- | 3.46 | -------- | 5.17 | ---- | 2.42 | 0.87 |
| 6127 | 5.57 | 2.38 | 7.95 | -------- | 1.81 | ---- | 3.09 | -------- | 4.90 | ---- | 1.84 | ---- |
| 6324 | 5.23 | 2.82 | 8.05 | -------- | 2.10 | ---- | 2.88 | -------- | 4.98 | ---- | 1.88 | 0.57 |
| 6391 | 6.12 | 1.78 | 7.90 | -------- | 1.50 | 0.49 | 3.46 | -------- | 5.46 | ---- | 2.12 | 1.02 |
| ---- | *6.00* | *1.50* | *7.50* | *Bn, Super G, T* | *1.00* | *1.00* | *3.00* | *Bn, G, T* | *5.00* | ---- | *1.50* | ---- |
| 6496 | ---- | ---- | 32.00 | -------- | ---- | ---- | ---- | -------- | ---- | ---- | ---- | ---- |
| ---- | ---- | ---- | *34.00* | -------- | ---- | ---- | ---- | -------- | ---- | ---- | ---- | ---- |
| 6153 | 18.50 | 0.30 | 18.80 | -------- | ---- | ---- | ---- | -------- | ---- | ---- | ---- | ---- |
| ---- | *17.00* | *1.00* | *18.00* | -------- | ---- | ---- | ---- | -------- | ---- | ---- | ---- | ---- |
| 6230 | 6.23 | 2.92 | 9.15 | -------- | 4.67 | ---- | ---- | -------- | 4.67 | 4.97 | 4.97 | 0.60 |
| 6283 | 6.81 | 2.14 | 8.95 | -------- | 5.92 | ---- | ---- | -------- | 5.92 | ---- | 4.88 | 0.62 |
| ---- | *8.00* | ---- | ---- | -------- | ---- | ---- | ---- | -------- | *6.00* | *6.00* | *6.00* | ---- |
| 6252 | 9.42 | 1.08 | 10.50 | -------- | 6.26 | ---- | ---- | -------- | 6.26 | ---- | 4.55 | 0.65 |
| ---- | *9.00* | ---- | ---- | -------- | ---- | ---- | ---- | -------- | *6.00* | *5.00* | *5.00* | ---- |

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Western Meat Company, San Francisco, Cal.** | | |
| 6084 | Blood, Diamond H | Dr. J. S. Carroll, Pomona | 62.08 |
| | *Guaranteed* | | *63.71* |
| 6093 | Blood, Diamond H | J. Henry Reynolds, Redlands | 61.95 |
| | *Guaranteed* | | *61.91* |
| 6104 | Blood, Diamond H | B. L. Byer, Upland | 60.81 |
| | *Guaranteed* | | *64.02* |
| 6289 | Blood, Diamond H | H. D. Derwin, Upland | 60.59 |
| | *Guaranteed* | | *59.88* |
| 6294 | Blood, Diamond H | Fruit Growers Supply Co., Los An. | 54.91 |
| 6295 | Blood, Diamond H | Redlands Fruit Assn., Redlands | 55.44 |
| 6296 | Blood, Diamond H | Fruit Growers Supply Co., Los An. | 55.13 |
| | *Guaranteed* | | *54.21* |
| 6318 | Blood, Diamond H | J. H. Reynolds, Redlands | 61.16 |
| | *Guaranteed* | | *59.75* |
| 6319 | Blood, Diamond H | J. H. Reynolds, Redlands | 61.42 |
| | *Guaranteed* | | *62.22* |
| 6368 | Blood, Diamond H | E. L. Koethen, Riverside | 61.42 |
| | *Guaranteed* | | *60.37* |
| 6521 | Blood, Diamond H | C. L. Nickle, Glendora | 59.58 |
| | *Guaranteed* | | *59.40* |
| 6528 | Blood, Diamond H | Chas. Page, Covina | 61.34 |
| | *Guaranteed* | | *62.92* |
| 6347* | Bone Meal | Benchley Fruit Co., Fullerton | 36.04 |
| | *Guaranteed* | | *35.10* |
| 6161* | Bone Meal, Diamond G | J. S. West, Modesto | 32.68 |
| | *Guaranteed* | | *32.85* |
| 6234* | Bone Meal, Diamond G | Bakersfield Sandst. Brick Co., B'field | 33.09 |
| | *Guaranteed* | | *33.06* |
| 6270* | Bone Meal, Diamond G | C. L. Nickle, Glendora | 34.63 |
| 6376* | Bone Meal, Diamond G | E. L. Koethen, Riverside | 35.18 |
| | *Guaranteed* | | *32.70* |
| 6095* | Bone Meal Special | J. H. Reynolds, Redlands | 33.37 |
| | *Guaranteed* | | *32.70* |
| 6135* | Bone Meal Special | P. J. Neilly, Pomona | 34.02 |
| | *Guaranteed* | | *33.06* |
| 6551* | Bone Meal Special | Alta Cresta Rancho, Riverside | 31.18 |
| | *Guaranteed* | | *30.30* |
| 6164 | Diamond B | Knutsen Bros., Turlock | 33.64 |
| | *Guaranteed* | | *30.40* |
| 6345 | Diamond C | Benchley Fruit Co., Fullerton | 33.57 |
| | *Guaranteed* | | *33.15* |
| 6469 | Diamond D | B. L. Byer, Upland | 30.96 |
| | *Guaranteed* | | *26.80* |

*6347—59% fine.
*6161—85% fine.
*6234—91% fine.
*6270—74% fine.
*6376—77% fine.
*6095—66% fine.
*6135—76% fine.
*6551—49% fine.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6084 | ---- | ---- | ---- | ---------- | ---- | ---- | 14.11 | ---------- | 14.11 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *14.48* | ---------- | *14.48* | ---- | ---- | ---- |
| 6093 | ---- | ---- | ---- | ---------- | ---- | ---- | 14.08 | ---------- | 14.08 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *14.07* | ---------- | *14.07* | ---- | ---- | ---- |
| 6104 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.82 | ---------- | 13.82 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *14.55* | ---------- | *14.55* | ---- | ---- | ---- |
| 6289 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.77 | ---------- | 13.77 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *13.61* | ---------- | *13.61* | ---- | ---- | ---- |
| 6294 | ---- | ---- | ---- | ---------- | ---- | ---- | 12.48 | ---------- | 12.48 | ---- | ---- | ---- |
| 6295 | ---- | ---- | ---- | ---------- | ---- | ---- | 12.60 | ---------- | 12.60 | ---- | ---- | ---- |
| 6296 | ---- | ---- | ---- | ---------- | ---- | ---- | 12.53 | ---------- | 12.53 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *12.32* | ---------- | *12.32* | ---- | ---- | ---- |
| 6318 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.90 | ---------- | 13.90 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *13.58* | ---------- | *13.58* | ---- | ---- | ---- |
| 6319 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.96 | ---------- | 13.96 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *14.14* | ---------- | *14.14* | ---- | ---- | ---- |
| 6368 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.96 | ---------- | 13.96 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *13.72* | ---------- | *13.72* | ---- | ---- | ---- |
| 6521 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.54 | ---------- | 13.54 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *13.50* | ---------- | *13.50* | ---- | ---- | ---- |
| 6528 | ---- | ---- | ---- | ---------- | ---- | ---- | 13.94 | ---------- | 13.94 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | ---- | ---- | *14.30* | ---------- | *14.30* | ---- | ---- | ---- |
| 6347 | ---- | ---- | 25.20 | ---------- | ---- | ---- | 3.18 | ---------- | 3.18 | ---- | ---- | ---- |
| ---- | ---- | ---- | *25.00* | ---------- | ---- | ---- | *3.00* | ---------- | *3.00* | ---- | ---- | ---- |
| 6161 | ---- | ---- | 32.20 | ---------- | ---- | ---- | 0.88 | ---------- | 0.88 | ---- | ---- | ---- |
| ---- | ---- | ---- | *32.30* | ---------- | ---- | ---- | *0.90* | ---------- | *0.90* | ---- | ---- | ---- |
| 6234 | ---- | ---- | 32.80 | ---------- | ---- | ---- | 0.85 | ---------- | 0.85 | ---- | ---- | ---- |
| ---- | ---- | ---- | *33.00* | ---------- | ---- | ---- | *0.80* | ---------- | *0.80* | ---- | ---- | ---- |
| 6270 | ---- | ---- | 29.10 | ---------- | ---- | ---- | 2.01 | ---------- | 2.01 | ---- | ---- | ---- |
| 6376 | ---- | ---- | 27.80 | ---------- | ---- | ---- | 2.42 | ---------- | 2.42 | ---- | ---- | ---- |
| ---- | ---- | ---- | *27.00* | ---------- | ---- | ---- | *2.00* | ---------- | *2.00* | ---- | ---- | ---- |
| 6095 | ---- | ---- | 27.70 | ---------- | ---- | ---- | 2.01 | ---------- | 2.01 | ---- | ---- | ---- |
| ---- | ---- | ---- | *27.00* | ---------- | ---- | ---- | *2.00* | ---------- | *2.00* | ---- | ---- | ---- |
| 6135 | ---- | ---- | 33.60 | ---------- | ---- | ---- | 0.90 | ---------- | 0.90 | ---- | ---- | ---- |
| ---- | ---- | ---- | *33.70* | ---------- | ---- | ---- | *0.65* | ---------- | *0.65* | ---- | ---- | ---- |
| 6551 | ---- | ---- | 22.60 | ---------- | ---- | ---- | 2.58 | ---------- | 2.58 | ---- | ---- | ---- |
| ---- | ---- | ---- | *22.00* | ---------- | ---- | ---- | *2.50* | ---------- | *2.50* | ---- | ---- | ---- |
| 6164 | 7.24 | 3.76 | 11.00 | ---------- | ---- | ---- | 3.18 | ---------- | 3.18 | 5.19 | 5.19 | 1.50 |
| ---- | *9.00* | *2.00* | *11.00* | *Bn, Super* | ---- | ---- | *2.50* | *Animal Matter* | *2.50* | *5.00* | *5.00* | ---- |
| 6345 | 5.80 | 3.70 | 9.50 | ---------- | ---- | ---- | 3.69 | ---------- | 3.69 | 4.76 | 4.76 | 0.80 |
| ---- | *7.00* | *2.50* | *9.50* | *Bn, Super* | ---- | ---- | *3.00* | *Animal Matter* | *3.00* | *6.00* | *6.00* | ---- |
| 6469 | 6.37 | 6.78 | 13.15 | ---------- | ---- | ---- | 3.09 | ---------- | 3.09 | 4.39 | 4.39 | 1.55 |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, Super* | *1.00* | ---- | *3.00* | *Animal Matter* | *4.00* | *2.00* | *2.00* | ---- |

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Western Meat Company—** Continued. | | |
| 6464* | Garbage Tankage | B. C. Swartz, Bloomington | ---- |
| | *Guaranteed* | | ---- |
| 6157 | Lemon Special | Johnston Fruit Co., Santa Barbara | 29.73 |
| | *Guaranteed* | | *26.13* |
| 6364 | Nitrate of Soda | E. L. Koethen, Riverside | 48.22 |
| | *Guaranteed* | | *48.00* |
| 6085 | Special | B. L. Byer, Upland | 34.79 |
| | *Guaranteed* | | *33.80* |
| 6107 | Special | B. L. Byer, Upland | 35.74 |
| | *Guaranteed* | | *34.40* |
| 6108 | Special | B. L. Byer, Upland | 41.77 |
| | *Guaranteed* | | *39.80* |
| 6113 | Special | J. H. Reynolds, Redlands | 36.19 |
| | *Guaranteed* | | *34.80* |
| 6115 | Special | J. H. Reynolds, Redlands | 29.92 |
| | *Guaranteed* | | *28.80* |
| 6369 | Special | E. L. Koethen, Riverside | 30.31 |
| | *Guaranteed* | | *26.80* |
| 6386* | Special | L. G. Baldwin, Upland | 45.37 |
| | *Guaranteed* | | *43.40* |
| 6394* | Special | F. D. Parker et al., San Fernando | 32.00 |
| 6480* | Special | R. H. Gibson, San Fernando | 31.78 |
| | *Guaranteed* | | *30.66* |
| 6517 | Special | Orange Hts. Fruit Assn., Corona | 26.11 |
| | *Guaranteed* | | *27.60* |
| 6546 | Special | J. H. Reynolds, Redlands | 30.98 |
| | *Guaranteed* | | *29.80* |
| 6105 | Superphosphate | B. L. Byer, Upland | 16.66 |
| | *Guaranteed* | | *15.98* |
| 6049* | Tankage | Alta Cresto Rancho, Riverside | 42.56 |
| | *Guaranteed* | | *41.65* |
| 6086* | Tankage | B. L. Byer, Upland | 36.41 |
| 6467* | Tankage | B. L. Byer, Upland | 38.35 |
| | *Guaranteed* | | *35.70* |
| 6096* | Tankage | J. H. Reynolds, Redlands | 43.37 |
| | *Guaranteed* | | *42.70* |
| 6097* | Tankage | J. H. Reynolds, Redlands | 38.28 |
| | *Guaranteed* | | *38.15* |

*6464—36% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6086—72% fine.
*6394—63% fine as bone, 88% fine as tankage.
*6480—86% fine.
*6049—80% fine.
*6086—76% fine.
*6467—82% fine.
*6096—81% fine.
*6097—71% fine.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6464 | ---- | ---- | 2.55 | ---------- | ---- | ---- | 3.10 | ---------- | 3.10 | ---- | 1.27 | 1.20 |
| ---- | ---- | ---- | *2.75* | ---------- | ---- | ---- | *3.00* | ---------- | *3.00* | ---- | *1.25* | ---- |
| 6157 | 7.82 | 2.08 | 9.90 | ---------- | 2.20 | 0.72 | 1.48 | ---------- | 4.40 | 2.63 | 2.63 | ---- |
| ---- | *8.00* | *2.00* | *10.00* | *Bn, Super* | *2.35* | *0.75* | *1.00* | *Animal Matter* | *4.10* | *1.50* | *1.50* | ---- |
| 6364 | ---- | ---- | ---- | ---------- | 15.07 | ---- | ---- | ---------- | 15.07 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | ---------- | *15.00* | ---- | ---- | ---------- | *15.00* | ---- | ---- | ---- |
| 6085 | ---- | ---- | 10.15 | ---------- | 1.83 | ---- | 2.19 | ---------- | 4.02 | 5.30 | 5.30 | 0.65 |
| ---- | ---- | ---- | *10.00* | *Bn, Super* | *2.00* | ---- | *2.00* | *Animal Matter* | *4.00* | *5.00* | *5.00* | ---- |
| 6107 | ---- | ---- | 7.90 | ---------- | ---- | 2.06 | 4.00 | ---------- | 6.06 | 2.62 | 2.62 | 1.00 |
| ---- | ---- | ---- | *8.00* | *Bn, Super* | ---- | *2.00* | *4.00* | *Animal Matter* | *6.00* | *2.00* | *2.00* | ---- |
| 6108 | ---- | ---- | 9.40 | ---------- | ---- | ---- | 4.54 | ---------- | 4.54 | 7.12 | 7.12 | 0.82 |
| ---- | ---- | ---- | *10.00* | *Bn* | ---- | ---- | *4.00* | *Animal Matter* | *4.00* | *7.00* | *7.00* | ---- |
| 6113 | ---- | ---- | 9.60 | ---------- | 1.17 | ---- | 3.03 | ---------- | 4.20 | 5.54 | 5.54 | 1.62 |
| ---- | ---- | ---- | *10.00* | *Bn, Super* | *1.00* | ---- | *3.00* | *Animal Matter* | *4.00* | *5.00* | *5.00* | ---- |
| 6115 | ---- | ---- | 9.55 | ---------- | 0.91 | ---- | 2.86 | ---------- | 3.77 | 3.20 | 3.20 | 1.32 |
| ---- | ---- | ---- | *10.00* | *Bn, Super* | *1.00* | ---- | *3.00* | *Animal Matter* | *4.00* | *2.00* | *2.00* | ---- |
| 6369 | ---- | ---- | 9.65 | ---------- | 2.86 | 0.62 | 1.16 | ---------- | 4.64 | 2.81 | 2.81 | 0.85 |
| ---- | ---- | ---- | *10.00* | *Bn* | *2.25* | *0.75* | *1.00* | *Animal Matter* | *4.00* | *2.00* | *2.00* | ---- |
| 6386 | ---- | ---- | 14.30 | ---------- | ---- | ---- | 8.42 | ---------- | 8.42 | ---- | ---- | ---- |
| ---- | ---- | ---- | *14.00* | *Bn* | ---- | ---- | *8.00* | *Animal Matter* | *8.00* | ---- | ---- | ---- |
| 6394 | ---- | ---- | 17.03 | ---------- | ---- | ---- | 4.78 | ---------- | 4.78 | ---- | ---- | ---- |
| 6480 | ---- | ---- | 17.80 | ---------- | ---- | ---- | 4.60 | ---------- | 4.60 | ---- | ---- | ---- |
| ---- | ---- | ---- | *18.00* | *Bn* | ---- | ---- | *4.30* | *Animal Matter* | *4.30* | ---- | ---- | ---- |
| 6517 | ---- | ---- | 9.45 | ---------- | ---- | ---- | 2.90 | ---------- | 2.90 | 2.71 | 2.71 | 0.85 |
| ---- | ---- | ---- | *10.00* | *Bn* | ---- | ---- | *3.00* | *Animal Matter* | *3.00* | *3.00* | *3.00* | ---- |
| 6546 | ---- | ---- | 10.30 | ---------- | ---- | ---- | 3.86 | ---------- | 3.86 | 2.75 | 2.75 | 1.55 |
| ---- | ---- | ---- | *10.00* | *Bn* | ---- | ---- | *4.00* | *Animal Matter* | *4.00* | *2.00* | *2.00* | ---- |
| 6105 | 17.72 | 0.58 | 18.30 | ---------- | ---- | ---- | ---- | ---------- | ---- | ---- | ---- | ---- |
| ---- | *17.00* | *1.00* | *18.00* | ---------- | ---- | ---- | ---- | ---------- | ---- | ---- | ---- | ---- |
| 6049 | ---- | ---- | 8.60 | ---------- | ---- | ---- | 8.70 | ---------- | 8.70 | ---- | ---- | ---- |
| ---- | ---- | ---- | *8.50* | ---------- | ---- | ---- | *8.50* | ---------- | *8.50* | ---- | ---- | ---- |
| 6086 | ---- | ---- | 9.30 | ---------- | ---- | ---- | 7.12 | ---------- | 7.12 | ---- | ---- | ---- |
| 6467 | ---- | ---- | 8.95 | ---------- | ---- | ---- | 7.64 | ---------- | 7.64 | ---- | ---- | ---- |
| ---- | ---- | ---- | *9.00* | ---------- | ---- | ---- | *7.00* | ---------- | *7.00* | ---- | ---- | ---- |
| 6096 | ---- | ---- | 9.15 | ---------- | ---- | ---- | 8.80 | ---------- | 8.80 | ---- | ---- | ---- |
| ---- | ---- | ---- | *8.80* | ---------- | ---- | ---- | *8.70* | ---------- | *8.70* | ---- | ---- | ---- |
| 6097 | ---- | ---- | 12.15 | ---------- | ---- | ---- | 7.09 | ---------- | 7.09 | ---- | ---- | ---- |
| ---- | ---- | ---- | *11.00* | ---------- | ---- | ---- | *7.25* | ---------- | *7.25* | ---- | ---- | ---- |

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Western Meat Company—** Continued. | | |
| 6106* | Tankage | B. L. Byer, Upland | 32.49 |
| 6508* | Tankage | P. A. Demmens, Alta Loma | 32.51 |
| | *Guaranteed* | | *31.50* |
| 6114* | Tankage | J. H. Reynolds, Redlands | 42.62 |
| | *Guaranteed* | | *42.28* |
| 6310* | Tankage | Orange Hts. Fruit Assn., Corona | 41.16 |
| 6311* | Tankage | Santiago Orange Growers Assn, Orange | 40.63 |
| 6312* | Tankage | Fruit Growers Supply Co., Los Angeles | 40.91 |
| | *Guaranteed* | | *43.05* |
| 6314* | Tankage | J. H. Reynolds, Redlands | 44.85 |
| | *Guaranteed* | | *45.85* |
| 6315* | Tankage | J. H. Reynolds, Redlands | 35.39 |
| | *Guaranteed* | | *36.27* |
| 6316* | Tankage | J. H. Reynolds, Redlands | 40.04 |
| | *Guaranteed* | | *39.97* |
| 6317* | Tankage | J. H. Reynolds, Redlands | 43.16 |
| | *Guaranteed* | | *44.09* |
| 6326* | Tankage | Stewart Cit. Assn., Upland | 45.05 |
| 6356* | Tankage | Stewart Cit. Assn., Upland | 46.19 |
| | *Guaranteed* | | *46.06* |
| 6346* | Tankage | Benchley Fruit Co., Fullerton | 43.43 |
| | *Guaranteed* | | *43.24* |
| 6353* | Tankage | Stewart Cit. Assn., Upland | 45.16 |
| | *Guaranteed* | | *45.75* |
| 6365* | Tankage | E. L. Koethen, Riverside | 40.47 |
| 6385* | Tankage | T. K. Vernon, Upland | 38.44 |
| 6468* | Tankage | B. L. Byer, Upland | 38.80 |
| 6494* | Tankage | G. L. Hutchinson, Colton | 40.30 |
| | *Guaranteed* | | *39.20* |
| 6366* | Tankage | E. L. Koethen, Riverside | 43.67 |
| 6432* | Tankage | F. G. Bush, Ontario | 43.54 |
| | *Guaranteed* | | *43.23* |
| 6367* | Tankage | E. L. Koethen, Riverside | 44.14 |
| | *Guaranteed* | | *44.21* |
| 6470* | Tankage | C. Huber, Los Angeles | 34.05 |
| | *Guaranteed* | | *33.46* |
| 6490* | Tankage | H. D. Derwin, Upland | 42.93 |
| | *Guaranteed* | | *44.07* |
| 6498* | Tankage | Elmer Hayward, Orange | 42.69 |
| | *Guaranteed* | | *40.85* |
| 6518* | Tankage | H. D. Derwin, Upland | 45.77 |
| | *Guaranteed* | | *46.03* |
| 6519* | Tankage | Orange Hts. Fruit Assn., Corona | 41.20 |
| | *Guaranteed* | | *40.95* |

*6106—85% fine.
*6508—84% fine.
*6114—79% fine.
*6310—81% fine.
*6311—81% fine.
*6312—81% fine.
*6314—76% fine.
*6315—79% fine.
*6316—76% fine.
*6317—76% fine.
*6326—83% fine.
*6356—79% fine.
*6346—77% fine.
*6353—78% fine.
*6365—81% fine.
*6385—87% fine.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6106 | ---- | ---- | 15.15 | ---------- | ---- | ---- | 5.21 | ---------- | 5.21 | ---- | ---- | ---- |
| 6508 | ---- | ---- | 14.40 | ---------- | ---- | ---- | 5.34 | ---------- | 5.34 | ---- | ---- | ---- |
| ---- | ---- | ---- | *15.00* | ---------- | ---- | ---- | *5.00* | ---------- | *5.00* | ---- | ---- | ---- |
| 6114 | ---- | ---- | 7.90 | ---------- | ---- | ---- | 8.83 | ---------- | 8.83 | ---- | ---- | ---- |
| ---- | ---- | ---- | *8.80* | ---------- | ---- | ---- | *8.60* | ---------- | *8.60* | ---- | ---- | ---- |
| 6310 | ---- | ---- | 13.50 | ---------- | ---- | ---- | 7.55 | ---------- | **7.55** | ---- | ---- | ---- |
| 6311 | ---- | ---- | 13.70 | ---------- | ---- | ---- | 7.39 | ---------- | **7.39** | ---- | ---- | ---- |
| 6312 | ---- | ---- | 13.80 | ---------- | ---- | ---- | 7.44 | ---------- | **7.44** | ---- | ---- | ---- |
| ---- | ---- | ---- | *13.50* | ---------- | ---- | ---- | *8.00* | ---------- | *8.00* | ---- | ---- | ---- |
| 6314 | ---- | ---- | 7.85 | ---------- | ---- | ---- | 9.37 | ---------- | **9.37** | ---- | ---- | ---- |
| ---- | ---- | ---- | *6.40* | ---------- | ---- | ---- | *9.85* | ---------- | *9.85* | ---- | ---- | ---- |
| 6315 | ---- | ---- | 11.20 | ---------- | ---- | ---- | 6.56 | ---------- | 6.56 | ---- | ---- | ---- |
| ---- | ---- | ---- | *11.50* | ---------- | ---- | ---- | *6.72* | ---------- | *6.72* | ---- | ---- | ---- |
| 6316 | ---- | ---- | 11.00 | ---------- | ---- | ---- | 7.70 | ---------- | 7.70 | ---- | ---- | ---- |
| ---- | ---- | ---- | *11.50* | ---------- | ---- | ---- | *7.60* | ---------- | *7.60* | ---- | ---- | ---- |
| 6317 | ---- | ---- | 7.90 | ---------- | ---- | ---- | 8.96 | ---------- | 8.96 | ---- | ---- | ---- |
| ---- | ---- | ---- | *7.79* | ---------- | ---- | ---- | *9.20* | ---------- | *9.20* | ---- | ---- | ---- |
| 6326 | ---- | ---- | 7.00 | ---------- | ---- | ---- | 9.56 | ---------- | 9.56 | ---- | ---- | ---- |
| 6356 | ---- | ---- | 7.55 | ---------- | ---- | ---- | 9.74 | ---------- | 9.74 | ---- | ---- | ---- |
| ---- | ---- | ---- | *7.00* | ---------- | ---- | ---- | *9.80* | ---------- | *9.80* | ---- | ---- | ---- |
| 6346 | ---- | ---- | 8.40 | ---------- | ---- | ---- | 8.94 | ---------- | 8.94 | ---- | ---- | ---- |
| ---- | ---- | ---- | *8.61* | ---------- | ---- | ---- | *8.86* | ---------- | *8.86* | ---- | ---- | ---- |
| 6353 | ---- | ---- | 7.75 | ---------- | ---- | ---- | 9.46 | ---------- | 9.46 | ---- | ---- | ---- |
| ---- | ---- | ---- | *7.15* | ---------- | ---- | ---- | *9.70* | ---------- | *9.70* | ---- | ---- | ---- |
| 6365 | ---- | ---- | 8.55 | ---------- | ---- | ---- | 8.21 | ---------- | 8.21 | ---- | ---- | ---- |
| 6385 | ---- | ---- | 9.50 | ---------- | ---- | ---- | 7.57 | ---------- | **7.57** | ---- | ---- | ---- |
| 6468 | ---- | ---- | 8.15 | ---------- | ---- | ---- | 7.88 | ---------- | 7.88 | ---- | ---- | ---- |
| 6494 | ---- | ---- | 11.25 | ---------- | ---- | ---- | 7.72 | ---------- | **7.72** | ---- | ---- | ---- |
| ---- | ---- | ---- | *8.00* | ---------- | ---- | ---- | *8.00* | ---------- | *8.00* | ---- | ---- | ---- |
| 6366 | ---- | ---- | 9.10 | ---------- | ---- | ---- | 8.88 | ---------- | 8.88 | ---- | ---- | ---- |
| 6432 | ---- | ---- | 8.80 | ---------- | ---- | ---- | 8.90 | ---------- | 8.90 | ---- | ---- | ---- |
| ---- | ---- | ---- | *8.00* | ---------- | ---- | ---- | *8.96* | ---------- | *8.96* | ---- | ---- | ---- |
| 6367 | ---- | ---- | 7.50 | ---------- | ---- | ---- | 9.26 | ---------- | 9.26 | ---- | ---- | ---- |
| ---- | ---- | ---- | *7.36* | ---------- | ---- | ---- | *9.30* | ---------- | *9.30* | ---- | ---- | ---- |
| 6470 | ---- | ---- | 14.50 | ---------- | ---- | ---- | 5.69 | ---------- | 5.69 | ---- | ---- | ---- |
| ---- | ---- | ---- | *15.40* | ---------- | ---- | ---- | *5.40* | ---------- | *5.40* | ---- | ---- | ---- |
| 6490 | ---- | ---- | 7.45 | ---------- | ---- | ---- | 8.98 | ---------- | **8.98** | ---- | ---- | ---- |
| ---- | ---- | ---- | *6.55* | ---------- | ---- | ---- | *9.40* | ---------- | *9.40* | ---- | ---- | ---- |
| 6498 | ---- | ---- | **7.40** | ---------- | ---- | ---- | 8.93 | ---------- | 8.93 | ---- | ---- | ---- |
| ---- | ---- | ---- | *8.50* | ---------- | ---- | ---- | *8.31* | ---------- | *8.31* | ---- | ---- | ---- |
| 6518 | ---- | ---- | 6.35 | ---------- | ---- | ---- | 9.84 | ---------- | 9.84 | ---- | ---- | ---- |
| ---- | ---- | ---- | *6.30* | ---------- | ---- | ---- | *9.91* | ---------- | *9.91* | ---- | ---- | ---- |
| 6519 | ---- | ---- | 12.95 | ---------- | ---- | ---- | 7.65 | ---------- | 7.65 | ---- | ---- | ---- |
| ---- | ---- | ---- | *13.50* | ---------- | ---- | ---- | *7.50* | ---------- | *7.50* | ---- | ---- | ---- |

*6468—90% fine.
*6494—73% fine.
*6366—70% fine.
*6432—69% fine.
*6367—76% fine.

*6470—86% fine.
*6490—86% fine.
*6498—83% fine.
*6518—71% fine.
*6519—76% fine.

| Laboratory Number | Name and Address of Manufacturer or Dealer, and Name of Brand. | From Whom Obtained. | Value per Ton at Station Prices. |
|---|---|---|---|
| | **Western Meat Company—** Continued. | | |
| 6540* | Tankage | W. J. Naftel, Pomona | 34.24 |
| | *Guaranteed* | | *31.86* |
| 6552* | Tankage | T. E. Ketcheson, Upland | 43.06 |
| | *Guaranteed* | | *43.37* |
| 6112* | Tankage, Diamond E | J. H. Reynolds, Redlands | 33.53 |
| 6545* | Tankage, Diamond E | J. H. Reynolds, Redlands | 36.15 |
| | *Guaranteed* | | *33.60* |
| 6094* | Tankage, Diamond I | J. H. Reynolds, Redlands | 32.33 |
| 6215* | Tankage, Diamond I | Bakersfield Sandst. Brick Co., B'field | 31.16 |
| | *Guaranteed* | | *32.10* |
| 6437 | Whale Blood Meal | W. A. Strong, Upland | 49.60 |
| | *Guaranteed* | | *50.40* |

*6540—43% fine.
*6552—78% fine.
*6112—81% fine.
*6545—86% fine.
*6094—75% fine.
*6215—80% fine.

| Laboratory Number | PHOSPHORIC ACID | | | | NITROGEN | | | | | POTASH | | CHLORIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From sulfate | Total | |
| 6540 | ---- | ---- | 14.35 | --------- | ---- | ---- | 5.76 | --------- | 5.76 | ---- | ---- | ---- |
| ---- | ---- | ---- | *14.80* | --------- | ---- | ---- | *5.12* | --------- | *5.12* | ---- | ---- | ---- |
| 6552 | ---- | ---- | 8.30 | --------- | ---- | ---- | 8.87 | --------- | 8.87 | ---- | ---- | ---- |
| ---- | ---- | ---- | *7.35* | --------- | ---- | ---- | *9.10* | --------- | *9.10* | ---- | ---- | ---- |
| 6112 | ---- | ---- | 16.40 | --------- | ---- | ---- | 5.25 | --------- | 5.25 | ---- | ---- | ---- |
| 6545 | ---- | ---- | 19.90 | --------- | ---- | ---- | 5.29 | --------- | 5.29 | ---- | ---- | ---- |
| ---- | ---- | ---- | *18.00* | --------- | ---- | ---- | *5.00* | --------- | *5.00* | ---- | ---- | ---- |
| 6094 | ---- | ---- | 13.25 | --------- | ---- | ---- | 5.49 | --------- | 5.49 | ---- | ---- | ---- |
| 6215 | ---- | ---- | 12.00 | --------- | ---- | ---- | 5.42 | --------- | 5.42 | ---- | ---- | ---- |
| ---- | ---- | ---- | *13.75* | --------- | ---- | ---- | *5.35* | --------- | *5.35* | ---- | ---- | ---- |
| 6437 | ---- | ---- | ---- | --------- | ---- | ---- | 11.81 | --------- | 11.81 | ---- | ---- | ---- |
| ---- | ---- | ---- | ---- | --------- | ---- | ---- | *12.00* | --------- | *12.00* | ---- | ---- | ---- |

UNIVERSITY OF CALIFORNIA PUBLICATIONS

COLLEGE OF AGRICULTURE

AGRICULTURAL EXPERIMENT STATION

BERKELEY, CALIFORNIA

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# GRAIN SORGHUMS

BY

B. A. MADSON

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**BULLETIN No. 278**

April, 1917

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UNIVERSITY OF CALIFORNIA PRESS

BERKELEY

1917

BENJAMIN IDE WHEELER, President of the University.

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* Died February 12, 1917.

†In co-operation with office of Public Roads and Rural Engineering, U. S. Department of Agriculture.

# GRAIN SORGHUMS

By B. A. MADSON

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### INTRODUCTION

The transition from extensive to more intensive methods of farming, together with the rapid development of the livestock industry which has taken place in California during the past few years, has created a demand for crops which would produce a dependable quan-

tity of grain and forage on the vast areas of unirrigated land during the dry, hot, summer months. The crops which have thus far shown the greatest promise in filling this demand are the grain sorghums. While they are by no means new crops in this state, they have been of relatively little importance agriculturally since their production has been confined largely to a few rather circumscribed localities. For this reason general information regarding their production is lacking, as is evidenced by the large number of inquiries received by this department during the past three or four years. It is, therefore, the purpose of this publication to set forth briefly the information which has been gathered through experimentation and observations, with the hope that it may be of service to the farmer who is contemplating the production of these crops.

## HISTORY IN CALIFORNIA

The history of the grain sorghums in this state, as well as in the United States, dates back to 1874, when a small consignment of White and Brown Durra was brought to California from Egypt. They were taken to the interior valleys, where they at once demonstrated their ability to withstand the hot, dry California summer, and very soon became established as a permanent crop. The Kafirs were introduced from the great plains a few years later and were followed in 1886 by Milo, which was brought from Texas. The latter crop soon demonstrated its superiority over the earlier introductions, and quickly attained a prominent place among the grain sorghums, a position which it has held to the present day,

While the grain sorghums have not risen into prominence as have some other crops, there, nevertheless, has been a normal and continual increase in their production. In 1899 the total acreage of grain sorghums in California was 20,218 acres, yielding 420,452 bushels of grain. In 1909 the acreage had increased to 44,308 acres, and the production to 938,049 bushels. Thus in ten years the acreage had increased 119.2 per cent, while the yield had increased 123.1 per cent. Unfortunately no statistics are available on the production since that date, but there is every reason to believe that the increase in production has been even greater than for the ten years given. Especially worthy of mention is the development of the grain sorghum industry in the Imperial Valley, in which section sorghum is at the present time one of the leading crops. The counties leading in the production of grain sorghums in 1909 were Tulare, Stanislaus, Kings, San Joaquin and Kern, in the order mentioned; the first three contained over one-half the total acreage of the state.

## ADAPTATION

*Climatic Requirements.*—The grain sorghums are of tropical origin, attaining their maximum development in regions having high temperatures and relatively low humidity during the growing season. Most of the varieties seem to be very susceptible to low temperatures, a fact which might militate against their use in sections where the average daily temperature during the growing season is low, or in sections having wide daily temperature ranges. Experiments and observations in this state, however, would seem to indicate that they can be grown successfully in all the interior valleys, and under these conditions constitute a very commendable substitute for corn. They have not, however, given as good results along the coast in regions subjected to the cool ocean breezes or at elevations above 5000 feet, though it is quite possible that varieties may yet be obtained which will give fair results even under these conditions.

*Drouth Resistance.*—All varieties of sorghums are drouth-resistant, and are considered among the surest of dry-land crops, though this quality is possessed to a greater degree by the grain sorghums than by any of the other types. Their ability to withstand drouth, however, is apparently due to their ability to make economical use of the water available rather than to their low water requirements.

While the grain sorghums as a class are comparatively shallow rooted, the roots are very much branched, completely filling the upper three feet of soil with a network of fine roots. This extensive root development, together with other physiological characteristics, enables them to utilize a larger proportion of the soil moisture than that used by most other plants. Furthermore most of the varieties are able to withstand a prolonged period of drouth without apparent injury.

Other things being equal, however, the yields obtained will usually be in direct proportion to the supply of moisture available. In many instances, with proper attention to details, good results have been obtained with a precipitation of eight to ten inches. When the precipitation is less than eight to ten inches, however, it is doubtful if paying returns can be obtained unless considerable moisture is carried over in the soil from previous seasons. With the annual precipitation greater than twelve inches good results can nearly always be obtained if proper precaution is taken to conserve the moisture.

*Soil Requirements.*—Grain sorghums may be grown on almost any soil that admits of ready cultivation. Like corn, they prefer a sweet soil, loamy in character and high in fertility. Very sandy soils or very heavy soils are not desirable. In the former type difficulty is often experienced in storing sufficient moisture for the use of the crop.

Heavy soils, on the other hand, are difficult to handle, and are apt to be cold and in poor physical condition at the time for planting, which may result in a poor stand.

Soils containing alkali are also objectionable but the sorghums are more resistant to alkali than most field crops. Nevertheless, large amounts of soluble salts in the soil will exert an injurious effect upon the growth of the plants, thus decreasing the yield.

## TYPES AND VARIETIES

The sorghums (*Andropogon sorghum*) include grain sorghums, sweet sorghums, broom corn, and probably also Sudan grass and Tunis grass, at least the relationship between the former and the latter two is very close. The division into agricultural groups or sub-species is based largely upon physical characteristics of the plants, and the purpose for which they are grown. Also rather closely related to the sorghums is Johnson grass (*Andropogon halipensis*), a well known weed pest in some portions of the state.

While the sorghums are self-fertile, a great deal of natural hybridization takes place under normal conditions, not only between varieties of the same type but between the various types. When different varieties of the sorghums or any of the sorghums and Sudan or Tunis grass are grown in adjacent fields, a large number of natural hybrids usually appear. This fact is significant as it shows the necessity of keeping the seed plats isolated in order to maintain a pure strain. Hybrids with Johnson grass, on the other hand, are apparently rare.

The grain sorghums are divided into groups as follows: Durras, Kafirs, Kaoliangs, and Shallu, this division being based largely on head and plant characteristics. The Durra group includes White and Brown Durra, Feterita and the Milos. As a whole they are early maturing, with rather short, dry, leafless stalks. The heads are thick, compact, ovate or egg shaped and may be either erect or pendent, depending upon the variety and cultural conditions. The White and Brown Durras, more commonly known as Jerusalem corn and Egyptian corn, have very dry, leafless stalks, with large, chaffy pendent heads and decidedly flattened seeds. The white-seeded variety shatters readily and is also often attacked by the birds. It is, however, the earliest maturing of the Durras.

Feterita, a rather recent introduction which has created considerable interest during the past few years, is rather tall, moderately leafy, with erect heads and plump bluish-white seed. It is early

maturing and apparently equally as drouth-resistant as the other forms, but its seed is rather soft and of low vitality so that difficulty is often experienced in securing a good stand.

The Milos have somewhat finer, juicier stems, are more leafy, and stool or sucker more profusely than the other Durras. The heads of the Milo may be either erect or pendent, with large, protruding seeds. The Standard Milo and the Dwarf Milo are both yellow-seed forms, the latter being a selection of the former, having been developed for its shorter stems, earlier maturity and greater drouth-resistance. The White Milo resembles the Standard Milo except that it has white seed instead of yellow.

Fig. 1.—With a good stand and on strong land dwarf Milo will produce abundant yields of both grain and forage. Note the taller hybrids in the background.

The Kafir group includes all the various varieties of Kafirs, most of which produce rather large, leafy, slightly juicy stalks and are rather late maturing. The Kafirs are further characterized by having erect, slender, cylindrical heads with somewhat smaller seeds than the Durras. Of this group the principal variety grown is the Black Hull White Kafir, though within recent years an Early Black Hull and a Dwarf Black Hull Kafir, have been developed by selection from the former type. The latter varieties resemble the former except that they are both shorter in stature and earlier maturing. The other varieties of Kafir, including the White, Pink and Red, both because of the poor yield and late maturing, have ceased to be important.

The Kaoliangs or Chinese sorghums have not been grown commercially in California as yet. As a class they are early maturing and possess small, dry, leafless stalks and erect, open heads. It is believed that they require less heat than either the Kafirs or the Durras and if this be true they might be of value at higher elevations or in sections where the growing season is too cool or too short for the latter types. As but little is known regarding their agricultural value, limited trials under the conditions mentioned are recommended before their production on a large scale is attempted.

Fig. 2.—Feterita is not so resistant to adverse moisture and temperature conditions at the time of germination as other grain sorghums, but when a good stand is secured the yields are high.

Shallu, more commonly known as Egyptian wheat, differs from the former types in that it has rather large, dry stalks, very loose open heads and small, hard seeds, which, however, possess a high degree of vitality. Because of the latter character it is usually easier to secure a good stand with Shallu on soils that are cold and wet or of poor physical condition than with any of the other varieties.

In order to secure some information as to the relative value of the different varieties as grain crops, a variety test was begun at the University Farm at Davis in 1913. This test included not only

the more common varieties but some of the more recent introductions as well. The yields obtained during the years 1913 to 1916 are given in Table I.

TABLE I

VARIETY TRIALS WITH GRAIN SORGHUMS

DAVIS

| C. I. No. | Variety | Yield per acre, pounds 1913 | 1914 | 1915 | 1916 | Ave. |
|---|---|---|---|---|---|---|
| | *Durras* | | | | | |
| 332 | Dwarf Milo | 2605 | 4450 | 5031 | 2214 | 3575 |
| 234 | Standard Milo | 1492 | 3480 | 4830 | 2362 | 3041 |
| ..... | White Milo | ..... | 2860 | 4693 | 1974 | 3176 |
| ..... | White Durra | 223 | 940 | 2520 | 378 | 1015 |
| ..... | Brown Durra | 2813 | 3200 | 5071 | 1521 | 3151 |
| 182 | Feterita | 3164 | 2380 | 3139 | 1953 | 2909 |
| | *Kafirs* | | | | | |
| 340 | Dwarf Black-Hull | 959 | 2220 | 3209 | 1460 | 1962 |
| 472 | Early Black-Hull | 618 | 2450 | 2520 | 483 | 1518 |
| 185 | Black-Hull White | 64 | 2600 | 1968 | 463 | 1274 |
| 342 | White Kafir | ..... | 1400 | 1533 | 1092 | 1342 |
| 34 | Red Kafir | 128 | 1250 | 1434 | 315 | 782 |
| ..... | Pink Kafir | ..... | 2475 | 2667 | 504 | 1883 |
| | *Kaoliangs* | | | | | |
| 310 | Brachets Black-Hull | ..... | ..... | 4662 | 777 | 2520 |
| 272 | White Kaoliang | ..... | ..... | 1071 | 325 | 698 |
| 170 | Manchu Brown | ..... | 2000 | 4436 | 777 | 2404 |
| 171 | Brown | ..... | 3700 | 4284 | 903 | 2962 |
| ..... | Shallu | ..... | 4200 | 4609 | 1816 | 3542 |

In studying the data given in the table it will be noted that there is considerable difference between the yields of any single variety for the different seasons. The relatively low yield of all varieties in 1913 was due to drouth, the total precipitation being less than nine inches. In 1916 the yields were also rather low. This, however, was due primarily to the poor stand obtained in most cases. In the absence of spring rains the soil became very dry before planting time, rendering the preparation of a good seed bed almost impossible. The conditions during the two seasons 1914 and 1915, on the other hand, were good and the results obtained were excellent.

Considering the average yield of the varieties by groups, it will be noted that of the Durras the highest yield was produced by Dwarf Milo, with 3575 pounds per acre, followed by White Milo, Brown Durra and Standard Milo, respectively. Attention is called to the fact, however, that the White Milo was not grown during the dry

season of 1913, but was grown only during the three most favorable seasons, and that the yield during these three seasons was lower than the yield of either Brown Durra or Standard Milo.

The lower yield of Feterita as compared with the former varieties is unquestionably due, in nearly all cases, to a poor stand. Nevertheless this factor is an important one when considering the relative merits of the different varieties. The low yield of the White Durra may be accounted for by losses through shattering and by attacks of

Fig. 3.—A plot of Dwarf Milo from selected heads. Note the large well-developed heads.

birds, 60 to 80 per cent of the grain usually being destroyed before it is mature.

Of the Kafirs the Dwarf Black-Hull Kafir gave the largest average yield, followed by Pink Kafir, Early Black-Hull, and Black-Hull White, respectively. The Dwarf and the Early Black-Hull are both more dwarfed in stature and earlier maturing than the Black-Hull White, and as grain crops are apparently better adapted to the conditions at Davis than the last named variety. The yield of the Pink Kafir has been fair, but it is very late in maturing and its seeds are rather dark and astringent, making it an undesirable variety to grow. The same in general may be said of the Red Kafir. The White Kafir, on the other hand, is a small, early maturing variety, but has little in its favor as a grain crop.

Of the Kaoliang group the best results have been obtained from Brown Kaoliang, though it must be stated that in manner and habit of growth, this variety and the Manchu Brown appear to be identical. Brachets Black-Hull Kaoliang, a rather dwarf, leafy variety, has given fair yields of grain during the two years it has been in the experiments. White Kaoliang, a very tall, though early maturing variety, is always attacked by birds, which accounts for its low yield.

The yield obtained from Shallu, it will be noted, is exceeded only by Dwarf Milo. This variety, however, was grown only during the last three years, giving it the advantage of the more favorable seasons.

Fig. 4.—Brown Kaoliang on the left, Dwarf Milo in the center, and White Kaoliang on the right.

It may be said, however, that the yield from Shallu is nearly always good and especially so when the supply of moisture is abundant. It is, however, later maturing and its seeds are small and hard, making them less desirable for feed than most of the other sorghums.

Considering the results as a whole the Durras have given higher yields than the varieties of any of the other groups, while the Dwarf Milo has been the most promising variety of the lot, and is without question the best variety for most conditions when a maximum yield of grain is desired. Regarding the other Durras, their relative worth will be determined by specific conditions and by the purpose for which they are to be grown. The yields of the Kafirs, on the whole

have been low, and it is questionable if they can be recommended for general use in this state except where grain and forage both are desired, and where the growing season is long.

A test including a few of the Durras and Kafirs was also conducted at the Kearney Park Station in 1913. In this test all the varieties were so badly injured by birds that the results were materially affected. An attempt was made to estimate the approximate percentage of injury in each case, which, together with the yields obtained, is given in Table II.

TABLE II

VARIETY TRIALS WITH GRAIN SORGHUMS
KEARNEY PARK, 1913

| Variety | Per cent destroyed by birds | Yield per acre, pounds |
|---|---|---|
| Dwarf Milo | 50 | 1739* |
| Standard Milo | 60 | 1731* |
| White Durra | 75 | 177† |
| Brown Durra | 55 | 1817† |
| Feterita | 40 | 1833 |
| Dwarf Black-Hull Kafir | 60 | 924 |
| Early Black-Hull Kafir | 60 | 770 |
| Black-Hull White Kafir | 50 | 429† |

* Average of three plots.
† Average of two plots.

The results here obtained were practically the same as the averages of the four years at Davis. While Feterita gave a slightly higher yield than the Milos and Brown Durra, only one plot of the variety was grown, and it may be stated that the Dwarf Milo plot adjacent to the Feterita plot yielded 2285 pounds per acre or 450 pounds more than the Feterita. Furthermore the Feterita was not so much damaged by the birds as were the other varieties.

All the Kafirs gave low yields but the order of their importance as indicated by yield was the same at Kearney Park as at Davis.

## CULTURE

Inasmuch as the grain sorghums are summer-grown crops, making their growth during the dry season of the year, too much emphasis cannot be placed upon the preparation of the seed bed and the care of the crop during the growing season. Especially is this important since the grain sorghums will, in most cases, be grown as a dry-land crop. We should not lose sight of the fact that although they are as a class drouth resistant, the yields which will be obtained will usually

be in direct proportion to the condition of the soil and the amount of moisture available. It is therefore desirable to handle the soil so that a good seed bed can be prepared and as much of the precipitation conserved as possible.

*Preparation of the Seed Bed.*—When possible the land should be plowed in the fall or early winter to a depth of eight or ten inches and allowed to lie in the rough until spring. In this condition the soil will absorb a large proportion of the winter rainfall and will also be materially benefited by weathering action. Unless the field is very weedy no further treatment will be necessary until it is to be prepared for seeding, at which time the seed bed can usually be prepared with a disc and harrow. If for any reason spring plowing becomes necessary it should always be more shallow than fall plowing, otherwise too much moisture will be lost by evaporation and difficulty will be experienced in working the land down properly for seeding. In fact, except on the most favorable soil more work is always required to prepare a good seed bed on spring-plowed than on fall-plowed land.

The seed bed should be smooth and even, with a mulch of two to three inches on the surface, while the soil below the mulch should be firm and moist. This condition is imperative as the seed of most of the grain sorghums is rather soft and rots easily if the soil is too cold or porous or the moisture supply insufficient for prompt germination. As has formerly been stated, such a seed bed can in most cases be prepared on fall-plowed land without difficulty with the ordinary implements found on the farm. Spring-plowed land, however, may require more work in order to pack the subsoil sufficiently and to pulverize the surface properly.

*Time of Seeding.*—The time to plant the grain sorghums will vary to some extent with the location and with the character of the soil. Planting should not be done until the soil and atmosphere are quite warm. In the valleys in the southern portion of the state where the warm weather begins earlier in the spring the crop may be planted earlier than in the north. Again, light, sandy soil warms up more quickly than heavy soil and can usually be planted a week to ten days earlier than the latter type. Results obtained at Davis indicate that in that section at least, the best time to plant is from the 10th to the 20th of April. If planted earlier the atmosphere and soil are too cold for the best growth. On the other hand, if planting is delayed until after the first of May the soil is apt to become too dry for prompt germination unless irrigation can be provided. On irrigated land seeding may be delayed until the middle or latter part of June, though the total yield will seldom be as great as when planting

is done earlier. In some places, however, this fact is made use of by employing the grain sorghums as a second crop to follow grain, grain-hay, or other similar spring crops.

*Method and Rate of Seeding.*—The most common method of planting the grain sorghums is to use a corn planter fitted with sorghum seed plates. With this implement the seed is drilled in rows three to three and one-half feet apart, spacing the seed from four to six inches apart in the row. In some cases the grain drill has been used for planting the crop by stopping up enough of the holes to give the proper spacing between rows. This implement, however, is not to be recommended as it seeds too shallow and too heavily for any but the most favorable conditions.

The distance commonly allowed between the rows is three and one-half feet, since this distance provides ample room for the development of the plants and for cultivation.

The distance between the plants in the rows will be governed by the character of the soil and the supply of moisture, and also by the variety employed. On fertile loam soils abundantly supplied with moisture, the heavier rates of seeding may be employed, while on sandy soils with a limited supply of moisture it is often advisable to allow a distance of even ten to twelve inches between the plants in the rows. Again such short varieties as Dwarf Milo and others of the Durras can ordinarily be seeded heavier than such large leafy types as the Kafirs, since the individual plants do not require as much moisture or as much space for development as do the plants of the latter type. In the case of the Milos especially, it is usually advisable to seed as heavily as conditions will permit, otherwise the plants stool profusely, causing uneven development of the heads as well as uneven ripening. All of the Durras and some of the Kafirs, if provided with ample room, will stool to some extent, but none of them stool as prolifically as the Milo.

The amount of seed ordinarily required per acre will be from two to six pounds. When planting the sorghum crop care should be exercised to see that the seed is placed below the surface mulch in contact with moist soil where it may quickly absorb the water needed for germination. This will usually be at a depth of from two to three inches. If the seed bed is rough and open, however, as is often the case on spring-plowed land, deeper planting may be advisable, though the maximum depth on ordinary soil is probably about four inches. If planted too shallow, the seed will be placed in the dry mulch, where germination will be delayed, which will often result in a poor, uneven stand.

When the surface of the soil is rough and open or the layer of dry soil so deep that it is difficult to get the seed down to moisture, good results have often been obtained by attaching shovel furrow openers on the shoes of the planter. These shovels provide small furrows by pushing the clods and dry soil aside, thus making it much easier to get the seed down to the moist soil below. This provides a condition much the same as that obtained by listing, except that the furrows are smaller and much shallower, being no deeper than necessary to get the seed below the mulch.

Listing sorghums has not been practiced to any great extent in this state, though it probably could be employed to advantage especially on light soil or for late planting. When planted with a lister the seed is planted in the bottom of a furrow several inches below the normal level of the ground. This furrow is allowed to remain open until the plants attain some size, when it is gradually filled in by the successive cultivations. When planted by this method the main roots of the plants are forced to develop several inches below the surface of the soil, making it possible to maintain a deeper mulch without injuring the roots.

On soils that are heavy or wet, however, listing may be a disadvantage since the soil in which the seed is planted may be too cold for rapid germination, or the bottom of the furrow may bake so hard that the young plants will be unable to force their way through.

*Care of the Crop.*—The attention necessary after the crop has been planted will depend wholly upon the condition of the field and the season. The sorghums grow rather slowly at first, and it often happens that the field becomes foul with weeds before the plants are large enough to permit regular cultivation. When this occurs the weed growth may be destroyed by the use of a harrow without severe injury to the crop, provided the teeth are set at an angle of forty-five degrees. Again, if the soil becomes crusted due to rains, as frequently occurs on heavy soils, the crust must be broken as the young seedlings are often too weak to push their way through. If the crust is not too thick it may be broken with a harrow, though it is usually better to use a corrugated or dunham roller, as this implement breaks the crust without injury to the plants. In general it may be said, however, that either the harrow or the roller can be employed with safety until the plants attain a height of four or five inches.

As soon as the plants are large enough so that the rows can be plainly seen the field should be cultivated, using an ordinary two-horse corn cultivator. This cultivation should be at least four inches in depth as the main object beside the destruction of weeds is the

establishing of a deep mulch. For this purpose an implement with rather small shovels is to be preferred since it pulverizes the soil more thoroughly and leaves the surface relatively smooth and even. Two or three similar cultivations should be given at intervals of from two to three weeks or until the plants attain a height of about three feet, after which no further cultivation will be necessary. Normally the crop will continue growth and mature without further attention.

*Irrigation.*—While the larger proportion of the grain sorghum crop will probably be grown without irrigation, occasions may arise under which irrigation may be advisable. Especially is this true when the sorghum is to be grown as a second crop following grain-hay or some similar spring crop. In such cases it will nearly always be necessary to irrigate the land before seeding.

The time of irrigating and the number of irrigations after the crop has been planted will depend wholly upon local conditions. Water should be applied when the plants appear to be affected by drouth. Except when the natural precipitation is very low one irrigation will usually be sufficient, this being applied when the plants start to head.

For irrigating the sorghums the furrow method may be employed, but if the land has previously been leveled and checked flooding is usually preferred because of the smaller amount of labor involved. After irrigation the field should be cultivated as soon as the soil is dry enough to work properly.

## HARVESTING THE GRAIN CROP

The time of ripening will depend not only upon the time of planting, but also upon the location, and the season, as well as the variety. Where the average daily temperature is high the crop will mature much more quickly than where it is low or in sections having cool nights. For example, in the Imperial Valley or in the southern part of the San Joaquin Valley, Dwarf Milo will often mature in 100 to 115 days after the plants are up, whereas at Davis, where the nights are relatively cool, 125 to 140 days are normally required. A similar variation in the time of maturity has been noted with the varieties requiring a longer season.

The grain crop should not be harvested until the majority of the heads are fully mature, since immature seed is apt to heat in storage, causing a considerable loss. The common means of harvesting this crop is to cut the heads by hand, throwing them into a wagon and hauling to the curing beds. By this method one man with a team can harvest from three-fourths of an acre to one acre per day, de-

pending upon the character of the field. Dwarf varieties with rather erect heads are sometimes harvested with a grain header. It is necessary, however, to modify the implement somewhat by raising the cutting device in order not to cut too much of the stalk. At best, some heads will be left in the field which must either be gathered by hand or pastured off by livestock. The corn binder is also employed to a slight extent, the stalks being cured in the field and later hauled to the barnyard and either headed or fed directly to livestock. Heading from the stack or shock, however, is much slower than heading from the standing crop. If the stalks are bound in bundles, however, they may be headed rather rapidly by laying the bundle on a block and cutting off the heads with a broadaxe or corn knife.

Fig. 5.—Harvesting Dwarf Milo at the University Farm.

After the heads are harvested they must be thoroughly cured. In sections where the conditions for drying are good the heads are usually placed in piles or ricks five to six feet in height, where they are allowed to remain for ten days, two weeks, or longer if necessary, until they are thoroughly dry. In sections where the conditions for drying are less favorable smaller piles must be used, otherwise the grains may spoil on the head. A method employed at the University Farm with good success is to spread straw on the ground to a depth of six to eight inches and then to spread the heads on the straw to a depth of a foot or eighteen inches, in which condition curing will take place rather quickly. When taken from the curing bed the straw is run through the thresher with the grains, thus preventing the usual loss due to shattering.

For threshing the grain sorghums, the ordinary grain thresher may be used if modified slightly. Most manufacturers of threshing machines supply special riddles to be used, which greatly facilitate the cleaning of the grains. The same riddles and sieves as are used for barley may be employed, though their use usually makes it necessary to reclean the seed after threshing. Another modification necessary is a removal of some of the concaves and a reduction in the

**Fig. 6.—Threshing Milo at the University Farm.**

speed of the cylinder, in order to prevent the cracking of a large percentage of the grains.

The grain is usually stored in bags rather than in bulk, since by this method it is easier to keep it from heating. Storing in bulk, however, may be practiced if it is kept perfectly dry and very large quantities are not placed in one bin. Because of the rather soft character of the seed, however, it absorbs moisture easily and will quickly spoil if not properly cared for. Even when placed in bags, the bags should be stored in as dry a place as possible, with ample circulation of air provided to keep it dry.

## GRAIN SORGHUMS AS FORAGE CROPS

The grain sorghums have not as yet been used extensively for forage, though it has been shown that when employed as stover, fodder or silage they compare favorably with corn. The choice of varieties for this purpose will naturally differ somewhat from the selection for grain alone. In general, the varieties which produce the largest vegetative growth and are the most palatable should be employed. In many respects the Kafirs are to be preferred since they not only produce a high tonnage but their stalks are leafy, somewhat juicy and quite palatable. The Milos are also excellent for this purpose, being apparently equally palatable to the Kafirs, though the tonnage which they will produce will ordinarily be less. Such varieties as White and Brown Durras or Shallu, because of their dry, pithy stalks, and lack of leaves, yield a low tonnage of forage of very poor quality.

Unfortunately no extensive tests have been conducted to determine the relative forage yields of the different varieties. During the seasons 1914 and 1915, however, the total green weight produced in the different cases on the Agronomy plots was determined by harvesting the whole plot as soon as the grain was mature and before the leaves had withered. The average yields of both grain and stalk, in tons per acre for the two years, of the varieties most suitable for forage purposes, were as follows:

| | Tons per acre |
|---|---|
| Dwarf Milo | 9.80 |
| Standard Milo | 9.93 |
| White Milo | 10.58 |
| Feterita | 7.01 |
| Dwarf Black-Hull Kafir | 12.35 |
| Early Black-Hull Kafir | 14.67 |
| Black-Hull White Kafir | 16.06 |

The cultural methods to employ when the crop is grown for forage are in most cases the same as those used for grain production. When the moisture supply is abundant it may be permissible, in most cases, to seed a little more heavily as by so doing the yield, as well as the quality of the forage, will be improved.

The proper time for harvesting will vary a little, depending upon the manner in which the forage is to be used; but since the stems and leaves of most of the grain sorghums remain green until after the seed is ripe, it is usually better to allow the seed to become mature before harvesting. If sorghums are to be used for silage this is

absolutely necessary in order to make the best quality of silage. If the product is to be fed as fodder the crop can be harvested when the seed is in the hard dough stage.

The sorghum forage crop may be harvested in exactly the same manner as corn. When the acreage is small, harvesting by hand or with a sled cutter will probably be most economical, but where large areas are to be handled it will usually pay to secure a corn binder which ties the plants into bundles, making them much easier to handle.

If the crop is to be used for silage it should be put into the silo as soon after cutting as possible, but if it is to be used as fodder the stalks or bundles should be put into shocks in the field and allowed to cure thoroughly, after which they may either be stacked or hauled directly to the feed rack.

## GRAIN SORGHUMS IN THE ROTATION

The use of the grain sorghums in the rotation has been a rather perplexing problem since they have the unsavory reputation of being "hard on the land." Just why this crop is hard on the land is not definitely known, but it is true that if such a rapid growing crop as barley is seeded on the land immediately following grain sorghums the yield will not be as good as if preceded by some other crop. It is probable that the sorghum, the root system of which is bunched near the surface, draws heavily on the available plant food and moisture, thus lessening the supply for the crop immediately following, especially if that crop is one which demands these constituents in relatively large quantities. It is evident that as compared with corn the grain sorghum leaves the soil in poor physical condition. Tests at the University Farm have shown, however, that if a couple of months elapse between the time the sorghum crop is removed and the seeding of the barley, the detrimental effect will be greatly lessened. When such a system is to be followed it is advisable to plow up the sorghum stubble as soon as the crop has been removed as areation will then be more thorough and the injurious effect more readily overcome. Wheat and oats are not affected as much as barley, while intertilled crops seem to be affected even less.

Another problem that will arise is the proper disposition of the stalks when they cannot be used for feed. While definite information is lacking as to the best means to dispose of them, it will probably be best to cut and remove them from the field, especially in sections where the moisture supply is low. While the writer is aware that this is contrary to the best agricultural teaching, yet it has been

found that with a low rainfall the soil moisture will be insufficient to rot so large a quantity of material and trouble will follow. Even when the stalks are removed, difficulty will sometimes be experienced in disposing of the stubble and roots. By using a fourteen or sixteen-inch mouldboard plow, however, the stubble may be turned under with a fair degree of success, but the ten or twelve-inch plows commonly found on California farms are too small to perform the job in a satisfactory manner. If the plowing is done in the fall or early winter, the large crowns will ordinarily be sufficiently disintegrated by spring so that they will not cause trouble when preparing for most spring crops. Sorghum, however, is not a good crop to precede alfalfa as even under the most favorable conditions the roots and stubble are apt to prove troublesome in leveling and checking the land as well as in seeding the alfalfa.

The grain sorghums may apparently follow almost any other crop with fair success, though it is not advisable to grow this crop on the same land year after year without the use of some other crop in the rotation. A system which is finding some favor where irrigation is available is to utilize the grain sorghum as a second crop following grain hay. The hay crop is removed in May or early June and the land irrigated and plowed and planted to sorghum. For this purpose an early maturing variety such as Milo, White Durra, or Feterita should be employed to avoid the possible danger of the crop being injured by frost before maturity. Even these varieties can not be planted later than the 20th of June without incurring the possible danger of injury by frost before maturity takes place in most sections of the state.

## SEED SELECTION AND IMPROVEMENT

As yet but little effort has been made to improve the grain sorghums, though from the small amount of work that has been done it is apparent that a great deal of progress can be made in this direction. By intelligent selection the yield of grain and forage may be greatly increased, as may also the earliness of maturity and drouth resistance. With such varieties as the Milos, which normally have rather pendent heads, it is possible, through careful selection, to develop in a very short time a strain with perfect heads. Many other similar lines of improvement will naturally suggest themselves, but the growers should bear in mind that it is much more difficult to fix several characters than one or two, for which reason only such characters should form the basis of selection as will be of value under his particular conditions.

While the majority of growers may not care to attempt improvement of the crop as above suggested, all are strongly urged to maintain seed plots, especially if they desire to grow the crop year after year. This is especially desirable as the seed on the market is often badly mixed with other varieties as well as badly hybridized with these varieties.

Inasmuch as all varieties of sorghums cross rather readily the seed plot should be maintained in an isolated part of the field where it will not be crossed by other varieties. The seed for this plot should be from heads or plants of a uniform type, for by careful selection of the few heads necessary to plant the seed plot, the grower is able not only to purify his strain, but to increase the yield and quality of his product as well.

## VALUE AS FEED

Relatively little information is available concerning the feeding value of the grain sorghums, especially as compared with the other cereals, but such tests as have been conducted indicate that when fed either as grain or in the form of fodder or silage they compare favorably with corn. It should be remembered, however, that the grain of the sorghums, like that of the other cereals, is not in itself a balanced ration, and will, therefore, give the best results only when fed in conjunction with some more concentrated feed.

In order to determine the relative composition of the different varieties analyses were made on the grain of the 1914 crop, the results of which, together with the analysis of corn and barley, are given in table III.

Comparing the average composition of all the grain sorghums with corn and barley it will be noted that they are but slightly lower in protein, fat, and crude fiber than corn, but higher in carbohydrates and ash. Barley is somewhat higher in protein, crude fiber and ash, but considerably lower in fat and carbohydrates.

A rather wide variation in the composition of the different varieties was obtained, but attention is called to the fact that the data given in the table represent but one analysis of each variety, and perhaps, therefore does not give an accurate comparison under all conditions.

As a grain feed, it is pretty well understood that there is some difference in value between the different types and varieties not shown in the composition. The Brown Durra and the Kafirs, for instance, are prone to have a constipating effect on the digestive system of animals unless fed with a laxative feed such as oilmeal or alfalfa.

TABLE III

COMPOSITION OF GRAIN SORGHUMS[1]
1914 CROP

| Variety | Per cent | | | | | |
|---|---|---|---|---|---|---|
| | Water | Protein | Fat | Crude fiber | Carbo-hydrates | Ash |
| *Durras* | | | | | | |
| Dwarf Milo | 10.05 | 8.99 | 3.35 | 1.91 | 74.25 | 1.45 |
| White Milo | 11.75 | 8.31 | 2.85 | 1.73 | 73.86 | 1.50 |
| White Durra | 11.00 | 10.58 | 3.62 | 1.30 | 71.36 | 2.14 |
| Brown Durra | 11.30 | 10.75 | 3.18 | 1.60 | 71.28 | 1.85 |
| Feterita | 11.35 | 9.49 | 2.12 | 1.33 | 74.21 | 1.50 |
| Average all Durras | 11.09 | 9.62 | 3.02 | 1.58 | 72.99 | 1.69 |
| *Kafirs* | | | | | | |
| Dwarf Black-Hull Kafir | 11.82 | 9.66 | 3.90 | 2.13 | 70.69 | 1.80 |
| Red Kafir | 12.75 | 9.49 | 3.10 | 1.68 | 71.32 | 1.66 |
| Pink Kaffir | 12.74 | 9.32 | 3.28 | 2.37 | 70.35 | 1.49 |
| Average all Kafirs | 12.44 | 9.49 | 3.43 | 2.06 | 70.79 | 1.65 |
| *Kaoliangs* | | | | | | |
| White Kaoliang | 10.82 | 11.68 | 3.90 | 2.45 | 68.59 | 2.56 |
| Manchu Brown Kaoliang | 9.78 | 9.32 | 3.71 | 1.33 | 74.48 | 1.38 |
| Brown Kaoliang | 10.19 | 10.25 | 3.36 | 1.75 | 72.27 | 2.18 |
| Brachets Black-Hull Kaoliang | 12.35 | 9.66 | 3.20 | 2.41 | 70.33 | 2.05 |
| Average all Kaoliangs | 10.78 | 10.23 | 3.54 | 1.98 | 71.42 | 2.04 |
| Shallu | 12.85 | 9.28 | 3.93 | 1.63 | 70.74 | 1.57 |
| Average all sorghums | 11.44 | 9.76 | 3.34 | 1.76 | 71.82 | 1.78 |
| Corn[2] | 10.60 | 10.30 | 5.00 | 2.20 | 70.40 | 1.50 |
| Barley[3] | 10.90 | 12.40 | 1.80 | 2.70 | 69.80 | 2.40 |

[1] Analyses of sorghums made by Professor M. E. Jaffa.
[2] and [3] Taken from Jordan's "Feeding of Farm Animals."

With the White Durra and the Milos, however, no effect of this character has been noted, a fact which renders them especially desirable as calf or poultry feeds. When the sorghums are used as grain feed much better results will usually be obtained if the seed is ground or crushed than if fed whole. When fed to livestock good results are also obtained by grinding or crushing the whole heads. The feed thus obtained compares favorably with corn and cob meal.

For fodder or silage purposes the value as a feed is governed to some extent by the variety and by the time of harvesting. However, where properly handled the fodder or silage from the Kafirs or Milos is but slightly inferior to corn. Much still remains to be learned, not only with regard to the value of the sorghums as feed, but also with regard to the most economical means of feeding them. When these problems have been more fully worked out and the value of the crops

as feed better understood it will doubtless lend a strong impetus to the production of this crop.

*Danger from Poisoning.*— Considerable apprehension is felt regarding the danger to stock from poisoning where the sorghums are fed green. It is true that plants which have been stunted in their growth sometimes develop prussic (hydrocyanic) acid in their leaves, which is quickly fatal to the animals which eat it. Most of the loss from poisoning, however, has occurred by pasturing stock on second-growth sorghums after the first crop has been removed. This second growth is made at a season of the year when the soil is dry and the conditions for growth not wholly favorable. The first growth seldom, if ever, causes trouble and can be either pastured or fed green without danger. In curing, the prussic acid disappears, so there is absolutely no danger in feeding the stover or fodder.

## ENEMIES OF THE GRAIN SORGHUMS

The grain sorghums grown in this state have been remarkably free from pests, either in the form of insects or diseases. The sorghum grain smut is sometimes met with, but seldom is the infection bad enough to occasion great loss. This disease resembles somewhat the stinking smut of wheat and can be controlled either by soaking the seed for fifteen minutes in hot water (132° to 134° F), or by dipping for ten minutes in a solution of formaldehyde (one pound of formaldehyde to forty gallons of water). After treatment the seed should be dried immediately and seeded as soon as possible. It is stated[4] on good authority that the Yellow Milo is immune to this disease.

Undoubtedly the most destructive pest of the grain sorghums in this state are blackbirds, and their control is not only difficult but probably impossible. Some of the varieties, such as White Durra and the White Kafir, are apparently preferred by the birds, but the other varieties are by no means immune to their attacks. This preference is sometimes made use of by planting a few rows of the varieties desired by the birds around the main field as a trap crop to attract the birds from the main portion of the field. It is necessary, however, to use a variety which matures as early as the main crop, the White Durra probably being the variety most commonly used.

[4] Farmers' Bulletin 288, p. 26.

## SUMMARY

1. The first introduction of grain sorghums into the United States occurred in 1874 when White and Brown Durra were brought to California from Egypt. Since that date their production in this state has increased gradually.

2. Sorghums prefer a warm, dry climate, relatively low in humidity. Localities with relatively cool conditions during the growing season or great daily temperature ranges are least suited to the growth of this crop.

3. The grain sorghums will withstand more drouth than most other field crops grown in California. However, since they are summer-grown crops, they must depend upon the water stored in the soil for their moisture supply. For this reason free-working loam soils with a large water-holding capacity are to be preferred.

4. Variety tests at the University Farm at Davis indicate that Dwarf Milo is the best variety for grain. All the Durras, however, are more prolific grain producers than the Kafirs.

5. In preparing the field for sorghums the land should be plowed in the fall or early winter to facilitate the absorption of moisture and the subsequent preparation of the seed bed. A well-prepared seed bed is necessary for sorghums in order to insure prompt germination of the seed.

6. The grain sorghums should not be planted until the soil and atmosphere are quite warm. At the University Farm the best results were obtained by planting between the dates of April 10 and 20. The corn planter fitted with sorghum seed plates is the implement commonly employed for planting the crop.

7. The amount of seed required per acre will vary from four to seven pounds, depending upon conditions. The distance between the rows and the rate of planting in the row must be governed by the variety and the amount of moisture available.

8. Listing sorghums has not been practiced to any great extent but may be advantageous on light dry soil or for late planting.

9. After the plants come up they should be cultivated often enough to keep the weeds in check and to maintain the mulch.

10. Grain sorghums are usually harvested by hand although the grain header or the corn binder may be employed. After harvesting it is necessary to cure the heads thoroughly before threshing, as the seed is otherwise apt to heat in storage.

11. For forage purposes the Kafirs and Milos, because of their juicy stems, are preferable to most of the other varieties. In using

the grain sorghums for silage the seed should be allowed to mature before harvesting in order to secure the best quality of silage.

12. Grain sorghums are hard on the soil and are not a good crop to precede such a rapid-growing crop as barley. This effect, however, can be overcome by plowing the field and allowing it to lie idle for a couple of months before seeding to another crop. Early maturing varieties of grain sorghums may be used as a second crop to follow grain hay.

13. Grain sorghums when fed either as grain fodder or silage are but slightly inferior to corn in feed value. Second-growth sorghums may develop prussic acid, which is poisonous to stock; the first crop, however, seldom if ever develops poison, nor is this found in the dry forage.

14. The worst enemies of grain sorghums in California are blackbirds, against which no adequate means of control have been devised.

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# IRRIGATION OF RICE IN CALIFORNIA

BY

RALPH D. ROBERTSON

Irrigation Engineer, Irrigation Investigations, Office of Public Roads and Rural Engineering
U. S. Department of Agriculture

(Based on work done at various periods during the years 1913–1916 in cooperation with the Office of Public Roads and Rural Engineering, U. S. Department of Agriculture, the California State Department of Engineering, the Office of Cereal Investigations of the Bureau of Plant Industry of the U. S. Department of Agriculture, and the California State Water Commission.)

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## IRRIGATION INVESTIGATIONS

(In cooperation with Office of Public Roads and Rural Engineering, U. S. Department of Agriculture, and State Engineering Department of California)

FRANK ADAMS S. H. BECKETT
H. A. WADSWORTH

SAMUEL FORTIER, Chief of Irrigation Investigations, Office of Public Roads and Rural Engineering.
W. F. MCCLURE, State Engineer of California.

---

* Died February 12, 1917.

† In co-operation with office of Public Roads and Rural Engineering, U. S. Department of Agriculture.

# IRRIGATION OF RICE IN CALIFORNIA

By RALPH D. ROBERTSON

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## INTRODUCTION

The purpose of this bulletin is to describe the irrigation of rice in California, principally in the Sacramento Valley, where about 95 per cent of the California crop was grown in 1916. Descriptions are presented of the methods of preparing land and of the implements used, together with such data regarding use of water on rice as will cover in general the range of questions that most frequently occur to prospective rice growers in California. In addition to data gathered on rice farms throughout the Sacramento and the San Joaquin valleys, information is presented that has been gathered at the Biggs rice field station of the Bureau of Plant Industry, U. S. Department of Agriculture, where cooperative irrigation experiments were conducted during the years 1914, 1915, and 1916. The introduction of rice into California agriculture has stimulated irrigation development and the main increase in the irrigated area of the Sacramento Valley the past few years has been due to the planting of this crop.

Rice in the Sacramento Valley has served a two-fold purpose of utilizing land heretofore not used except for scanty pasture or on which grain growing has been declining through decreased production, and of providing a means of utilizing the waters of irrigation systems which had been constructed but which had not been fully developed on account of lack of settlers. As is to be expected, the industry has attracted people from Japan, China, and India, where rice is one of the principal crops grown, as well as people from the rice sections of Arkansas, Louisiana, and Texas. In many instances these settlers from other states or foreign countries have introduced some customs or practices common to their old environments, but find in California peculiar soil or climatic conditions that may call for entirely new methods. In view of this, a description of methods found best suited to California should be of value.

## WATER SUPPLY AND ITS USE

Approximately 67,000 acres of rice were irrigated in California in 1916. Of this area about 29,500 acres were irrigated from Sacramento River, about 24,000 acres from Feather River, about 9800 acres from other streams, and about 3700 acres with water pumped from wells. The first commercial crop of rice in California was grown in 1912 on 1400 acres, and the area in 1916 was more than twice that planted in 1915.

The Sutter-Butte Canal, which takes its supply from Feather River about ten miles above Gridley, served the largest area of rice

in Sacramento Valley in 1916, amounting to 17,000 acres. The Western Canal, which heads in Feather River shortly above Sutter-Butte Canal, served 5500 acres. The Sacramento Valley West Side Canal, which derives its supply from Sacramento River, supplied water to 8500 acres in Glenn and Colusa counties. The Yolo Water and Power Canal, diverting from Cache Creek, irrigated about 6000 acres. Other large enterprises, which obtained water by pumping from Sacramento River, were the Moulton Irrigated Land Company, California Land and Rice Products Company, Cheney Slough Irrigation Company, Mallon-Blevins Company, and River Gardens Farms Company.

The only canal company in the Sacramento Valley serving water for rice irrigation which has as yet sold water on an acre-foot basis is the Yolo Water and Power Company, which charges $1.50 per acre-foot. The Sutter-Butte Canal Company has furnished water for rice to lands having water rights at an annual charge of $5 per acre. Recent contracts made by this company are on the basis of $7 per acre, with reimbursements to the water user for the construction of ditches and for rights of way, provided water has been used for more than two successive years. The amount of water called for in the Sutter-Butte contracts is at the rate of one cubic foot per second for each 53⅓ acres. The Sacramento Valley West Side Canal Company, by authority of the California State Railroad Commission, charged $7 per acre for rice. For this charge the water user was entitled to five acre-feet of water per acre, additional amounts to be charged for at the rate of $1.50 per acre-foot. However, no cases are known in which water used in excess of five acre-feet was charged for.

Pumping from wells for rice irrigation in California has been chiefly resorted to in the San Joaquin Valley, but to a limited extent also in the Sacramento Valley. There are many opportunities for this type of development where water can be obtained by low lifts from wells or streams either for the entire season or for a portion of the season in supplementing a gravity supply. Owing to the large water-requirements of rice and the steady demand for water throughout a long season, wells should be thoroughly tested before rice is planted and failures can be avoided by keeping the acreage commensurate with the water supply. The charge for electric power in the Tulare and Kern sections of the San Joaquin Valley is $42.30 per horsepower per annum and in the Sacramento Valley the usual rate for the smaller plants is approximately two to two and one-half cents per kilowatt hour, depending upon the size of the plant and the character of the contract. Engines burning cheap oil or distillate

may also be used. Centrifugal pumps, on account of their adaptability and ease of operation, are the most common type of pump. Twelve-inch wells are commonly used, and the usual contract price for drilling is $1.50 per foot for the first 100 feet and an increase of fifty cents a foot for each additional fifty feet.

A study of reports of the United States Geological Survey will assist those who propose to engage in pumping from wells.[1]

## PREPARATION OF LAND

Land is prepared for rice in contour checks, the difference in elevation between checks varying from .25 to .30 foot where the slope of the country is from two feet to five feet per mile. Usually a surveyor is employed to lay out the field and the cost of surveying amounts to from twenty-five to fifty cents per acre. One of the most rapid methods of locating the contours, in which no stakes are required, is to have the rodman mark the location by shaking a small amount of lime on the ground from a sack. After a few points have been located on a contour, a plow team connects the points by plowing four to six furrows which form the base of the levee. Sometimes the contours or field levees are marked by lath stakes, and to avoid confusion where the contours come close together a good plan is to tie a rag of a certain color on the stakes marking one contour and to use a rag of a different color on another contour. Sharp turns in the levees should be avoided wherever possible.

Figure 1 shows a 160-acre rice field prepared for irrigation. The head ditch extends along the north line or upper end of the field and follows part way along the east side. A drainage ditch is provided at the lower end along the south side of the field, and also along the west side. The field is divided into eleven checks, the contour interval or difference in elevation between checks being .30 foot. It will be noted that there is a direct inlet and outlet provided for each check and also that several gates are placed in interior levees to admit water from one check to another. This arrangement provides good control of water from the head ditch and also offers advantages in draining the field. In case of a break in the ditch or levees the water may be quickly removed and repairs can also be made in one part of the field without interrupting the service in another.

The outside levee is made stronger than the interior or field levees and should have a base of six to eight feet and a height of 1.5 to 2.5

[1] Ground Water for Irrigation in the Sacramento Valley, California: U. S. Geol. Survey Water-Supply Paper 375A. Ground Water in the San Joaquin Valley, California: U. S. Geol. Survey, Water Supply Paper 398.

feet. There is probably no more satisfactory implement for making a strong levee than the Fresno scraper, because the team in passing back and forth over the freshly moved earth packs it down securely. The interior levees are more commonly made with a checker or ridger drawn by a tractor. Figure 2 shows a checker in use. This implement is provided with a device for raising or lowering the rear end,

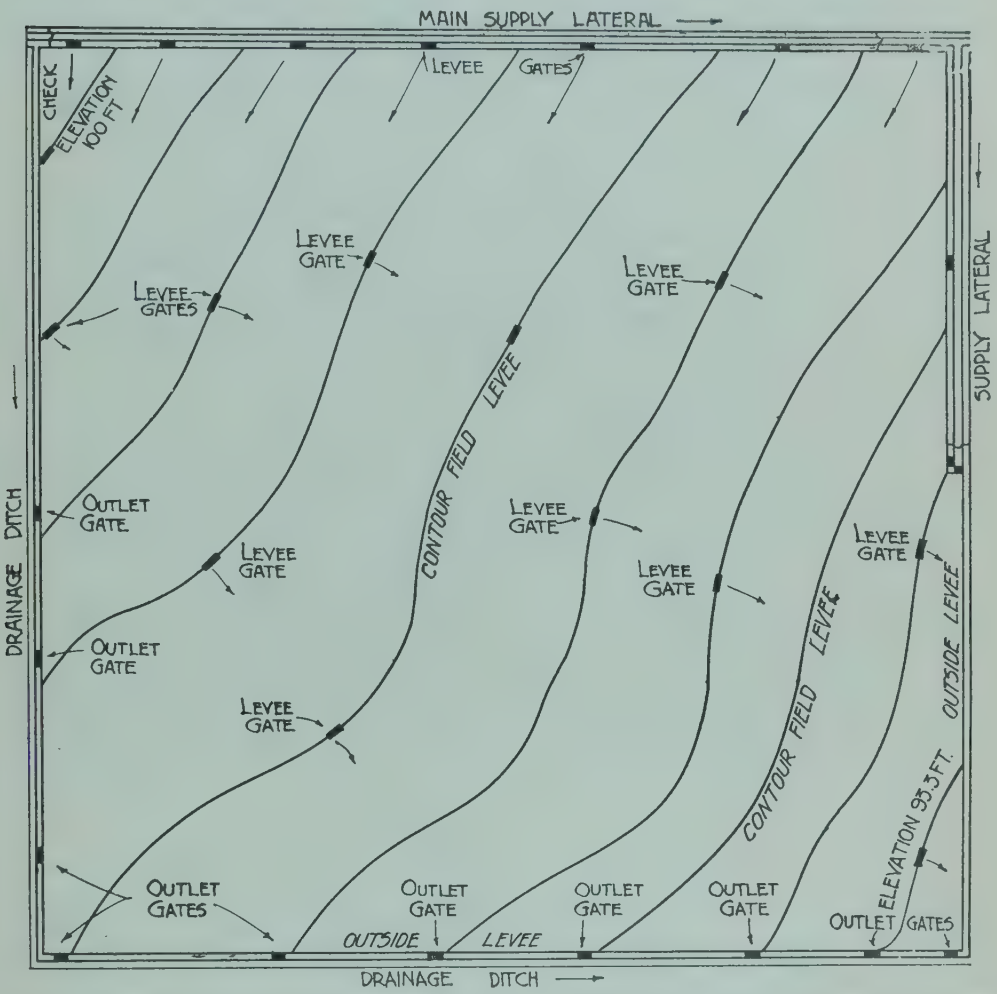


Fig. 1.—160-acre rice field, showing good arrangement of supply, drainage ditch, and contour levees.

enabling the operator to regulate the size of the levee. More often a simple home-made implement is used such as is shown in figure 3, the cost of which is about $50. The runners for sides are made of three-inch by twelve-inch plank twenty feet in length and are lined with steel. The front end is made ten feet wide on the bottom and the rear end is three feet wide on the bottom. The sides are made two feet high and are set on a batten of one-fourth to one, the tops sloping

outward. This implement makes a levee having a base of about five feet and a height when settled of about twelve inches. On fairly even ground a crew of two or three men with a tractor frequently check 150 acres or more per day. Often the work is contracted and a common price paid is $50 per day for the use of the tractor and checker. Sometimes the levees are made with a "V" crowder which is also widely used in making field ditches. Recently a "V" made of steel and reversible has come into use.

In most sections no attempt has been made to level or grade the land within a check, the preparation of land consisting mainly in building the supply ditches and constructing the levees. In the

Fig. 2.—Making levee in rice field with tractor and checker in Sacramento Valley, California.

vicinity of Willows large drags or floats drawn by tractors are used to smooth the surface after the land is plowed (fig. 4). It is doubtful if much leveling of land is justified because in fields where knolls or hummocks have been removed to fill in low places it has been found that in the "fills" the plant develops a rank growth of straw and the heads are not filled, while in the heavily-scraped portions of the field the plant is stunted in growth. On the other hand it must be kept in mind that a uniform depth of water over the field is highly desirable. If the depth of water is not fairly uniform there is a difference in the time of maturity of the rice and the yields are also affected, as shown in the experiments at Biggs reported later in table 3. The amount of work and expense justified in preparing the field must therefore rest largely on the judgment of the grower.

The universal practice has been to harvest within a single check on account of the obstructions offered to the passage of machinery by the present type of field levee. It is possible that as the industry

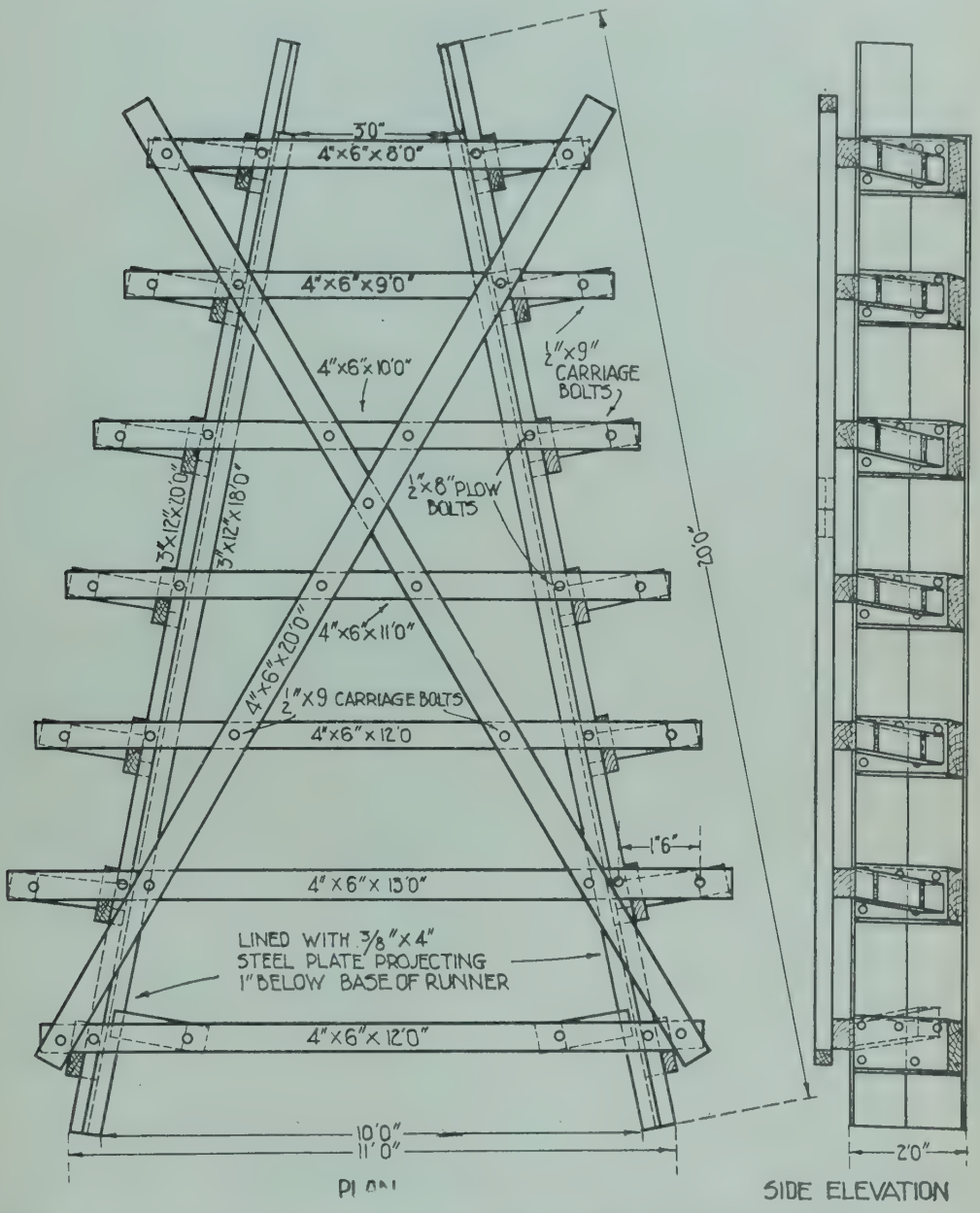


Fig. 3.—Homemade checker or levee ridger as used in rice fields in Sacramento Valley, California.

advances more permanent levees with a base of about ten feet and gentle side slopes will be used. The advantages of broad levees, besides those of ease and cheapness in planting and harvesting, are that the cultivated area is increased and weed growth can be better

controlled. It can not be expected, however, that the growth of rice on the levees will yield any appreciable amount.

## GATES

Gates are necessary in the canal banks to admit water to the checks and also in the field levees for admitting water from one check to another. The canal structures are of the ordinary type used in irrigation, but the gates in the field levees are less substantial than those usually employed for alfalfa irrigation. It is important to have the gates sufficiently wide to admit the large heads of water used in the initial floodings. Figure 5 shows a simple form of wooden gate which can be installed for about fifty cents. Where the gate is more than

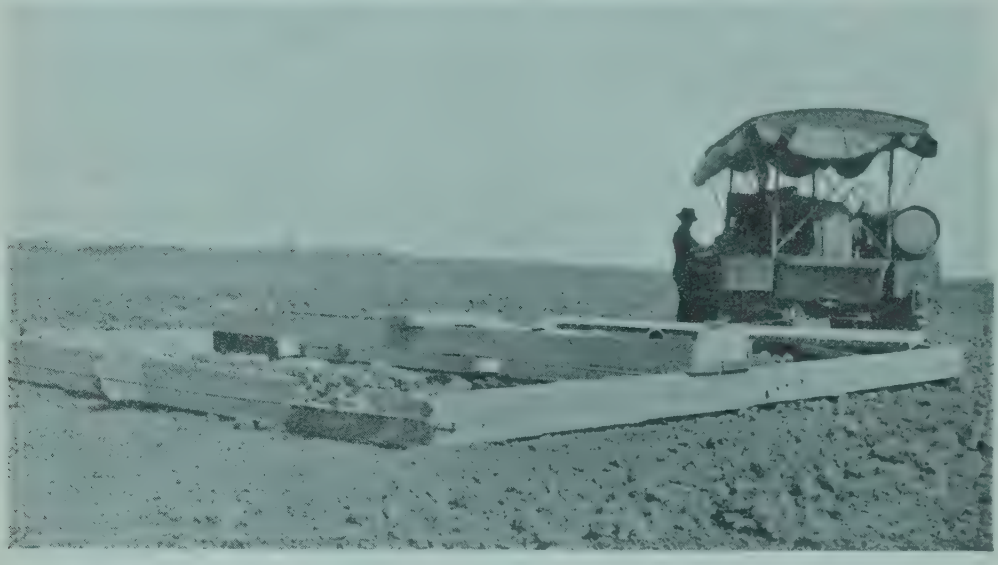

Fig. 4.—Heavy drag or leveller used in preparing rice land for irrigation in Sacramento Valley.

four feet wide a center division support is used. Box tubes which are sometimes placed through the levees are not generally satisfactory. The gates should be well tamped and preferably puddled in, at the time of placing them, to prevent leaks.

## APPLICATION OF WATER

The irrigation season is divided into two main periods. In the first period irrigations are given to keep the soil moist, but without having the water stand on the field. In the second period the field is continually submerged. It has been found necessary to irrigate after planting to germinate the seed and to give enough subsequent waterings to maintain growth until the plant is from four to six inches high. The best time to begin submergence, according to the experiments

at Biggs, is about thirty days after the emergence of the plant above ground. The principal reason for not permitting water to stand on the field during the germination period is the danger of the seed rotting in the ground, especially if weather conditions are unfavorable and the soil is cold. As a rule, water should not be allowed to remain on the land more than one or two days after the initial flood-

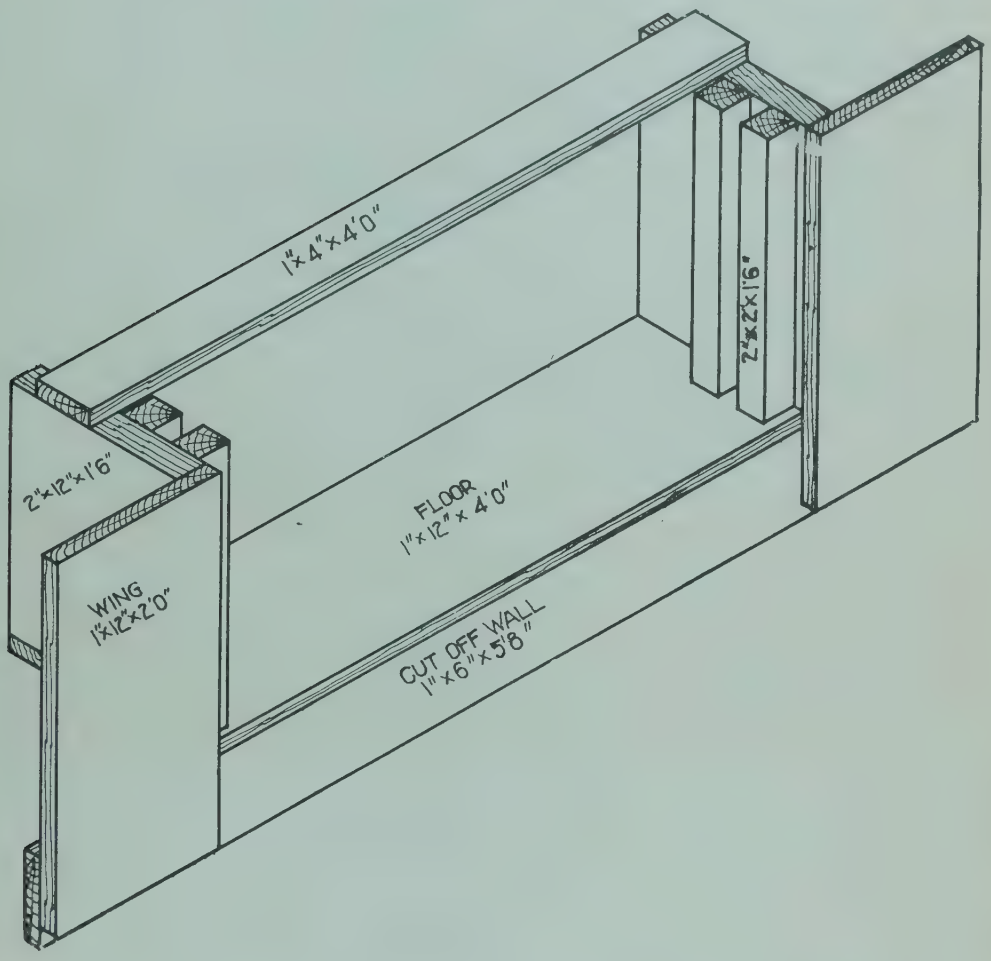


Fig. 5.—A satisfactory gate for use in inside rice levees.

ings. The use of heads of water varying from two to five cubic feet per second or more facilitates quick watering at this time. During submergence the heads need not be so large.

In beginning submergence the water should be gradually raised until an average depth of six inches is attained. Likewise at the close of the submergence period the water should be gradually lowered and not hurriedly removed, a rapid draining having a tendency to weaken the straw. Care should be exercised when draining the fields not to cause injury to lower areas. Much damage has resulted to

## TABLE 1

### Summary of Measurements of Duty of Water for Rice on Eighteen Fields in Sacramento Valley, California, 1916

| Name and location | Area, acres | Soil type | Source of water supply | Date of first irrigation | Date of beginning submergence | Date water turned off | Length of irrigation season, days: Prior to submergence | Length of irrigation season, days: Period of submergence | Length of irrigation season, days: Total | Number of irrigations prior to submergence | Depth of water used prior to submergence, feet | Depth of water used during submergence, feet. | Total depth applied, feet | Estimated or measured surface waste, acre feet per acre | Net depth applied, feet | Average area served per cu. ft. per second, acres: Period of submergence | Average area served per cu. ft. per second, acres: Whole season | Approximate depth to ground water, feet: Beginning of season | Approximate depth to ground water, feet: End of season | Yield of paddy rice, sacks per acre (averaging 100 pounds each) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | WEST SIDE | | | | | | | | | | | | | | | |
| Harlan & Scheeline, No. 1: NE. ¼ Sec. 36, T. 20 N., R. 3 W. | 135.60 | Tehama clay loams and clay. | Sacramento Valley West-side Canal. | April 26 | June 21 | Oct. 12 | 56 | 114 | 170 | 9 | 1.95 | 5.85 | 7.80 | 0.0 | 7.80 | 39 | 44 | 6.0 | 4.0 | 33 |
| Harlan & Scheeline, No. 2: SW. ¼ Sec. 6, T. 19 N., R. 2 W. | 132.53 | Tehama clay loams and clay. | Sacramento Valley West-side Canal. | May 3 | June 24 | Oct. 22 | 52 | 121 | 173 | 7 | 2.23 | 6.22 | 8.45 | 2 | 8.45 | 38 | 41 | 6.0 | 4.5 | 25 |
| Ole Johnson, No. 1: NW. ¼ Sec. 18, T. 18 N., R. 3 W. | 26.26 | Willows loams, Willows clay adobe. | Sacramento Valley West-side Canal. | May 8 | June 14 | Oct. 30 | 37 | 139 | 176 | 4 | 2.69 | 12.14 | 14.83 | 3 | ..... | 23 | 24 | 5.5 | 0.5 | 15 |
| Ole Johnson, No. 2: SE. ¼ Sec. 18, T. 18 N., R. 3 W. | 75.50 | Willows clay adobe. | Sacramento Valley West-side Canal. | May 17 | July 1 | Oct. 29 | 45 | 121 | 166 | 4 | 1.42 | 5.76 | 7.18 | 0.72 | 6.46 | 49 | 52 | 5.5 | 1.5 | 18 |
| M. McDermott: NE. ¼ Sec. 33, T. 17 N., R. 3 W. | 61.00 | Willows loams ..... | Sacramento Valley West-side Canal. | April 19 | May 19 | Oct. 24 | 30 | 159 | 189 | 5 | 1.45 | 10.72 | 12.17 | 3.10 | 9.07 | 42 | 42 | 6.5 | 4.0 | 47 |
| Shaver & Edwards: NE. ¼ Sec. 20, T. 18 N. R. 3 W. | 44.85 | Willows loams, Willows clay. | Sacramento Valley West-side Canal. | May 22 | July 6 | Oct. 23 | 45 | 110 | 155 | 5 | 1.00 | 6.58 | 7.58 | 0.90 | 6.68 | 39 | 46 | 6.8 | 3.6 | 35 |
| Spalding Company: Secs. 22, 23, 26 and 27, T. 18 N., R. 3 W. | 866.00 | Willows clay..... | Sacramento Valley West-side Canal. | April 23 | 1 | Oct. 25 | 1 | 1 | 186 | 1 | 1 | 1 | 7.39 | 1.00 | 6.39 | 1 | 57 | 6.0 | 5.5 | 25 |
| A. Quatman: SW. ¼ Sec. 6, T. 19 N., R. 3 W. | 70.15 | Willows clay..... | Pumping from wells. | April 26 | 1 | Oct. 21 | 1 | 1 | 179 | 1 | 1 | 1 | 6.49 | 0.0 | 6.49 | 1 | 55 | 12.0 | 12.0 | 20 |
| Mallon & Blevins: Secs. 14 and 15, T. 17 N., R. 2 W. | 1106.00 | Sacramento clays... | Pumping from Sacramento River. | April 17 | 1 | Sept. 27 | 1 | 1 | 164 | 1 | 1 | 1 | 6.71 | 1.30 | 5.41 | 1 | 61 | 4.0 | 3.0 | 35 |

## East Side

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| E. L. Adams: NE. ¼ Sec. 34, T. 19 N., R. 2 E. | 39.50 | Stockton clay adobe | Sutter-Butte Canal. | April 13 | June 9 | Sept. 30 | 57 | 114 | 171 | 6 | 1.01 | 3.26 | 4.27 | 0.0 | 4.27 | 70 | 80 | 1.5 | 1.0 | 39 |
| Baker Bros.: S. ½ Sec. 28, T. 19 N., R. 2 E. | 229.50 | Stockton clay adobe | Sutter-Butte Canal. | April 21 | June 14 | Oct. 9 | 54 | 118 | 172 | 6 | 0.82 | 3.84 | 4.66 | 0.0 | 4.66 | 61 | 73 | 1.5 | 1.0 | 42[7] |
| Evans Bros.: SW. ¼ Sec. 22, NW. ¼ Sec 27, T. 19 N., R. 2 E. | 187.23 | Stockton clay adobe | Sutter-Butte Canal. | April 28 | June 17 | Oct. 4 | 50 | 110 | 160 | 7 | 1.14 | 3.66 | 4.80 | 0.0 | 4.80 | 60 | 67 | 1.5 | 1.0 | 34 |
| Carl Lindberg: W. ½ Sec. 18, T. 19 N., R. 2 E. | 38.80 | Stockton clay adobe | Sutter-Butte Canal. | April 28 | June 13 | Oct. 14 | 46 | 124 | 170 | 6 | 1.91 | 7.44 | 9.35 | [3] | ..... | 33 | 36 | 1.5 | 1.0 | 47 |
| Dodge Rice Company: N. ½ Sec. 29, T. 20 N., R. 1 E. | 41.00 | Stockton clay adobe | Western Canal ... | May 3 | July 12 | Sept. 26 | 70 | 77 | 147 | 6 | 2.50 | 5.78 | 8.28 | 1.02[4] | 7.26 | 32 | 41 | 1.5 | 1.0 | 39 |
| Conklin & Noyer: SE. ¼ Sec. 27, T. 16 N., R. 4 E. | 36.70 | San Joaquin loams | Hallwood Canal.. | April 14 | June 13 | Sept. 29 | 60 | 109 | 169 | 5 | 2.33 | 10.08 | 12.41 | 2.41 | 10.00 | 28 | 34 | ..... | 3.0 | 10 |
| Byron Jakes (east field): NW. ¼ Sec. 28, T. 16 N., R. 4 E. | 13.95 | San Joaquin loams | Hallwood Canal.. | April 18 | June 23 | Oct. 9 | 66 | 109 | 175 | 5 | 1.44 | 13.94 | 15.38 | 1.95 | 13.43[5] | 18 | 26 | ..... | 3.0 | 14 |
| Byron Jakes (west field): NW. ¼ Sec. 28, T. 16 N., R. 4 E. | 28.00 | San Joaquin loams | Hallwood Canal.. | April 15 | June 24 | Oct. 10 | 70 | 109 | 179 | 6 | 3.01 | 15.69 | 18.70 | 5.88[3] | ..... | 22 | 28 | ..... | 3.0 | 18 |
| Schell & Woodruff: W. ½ Sec. 30, T. 16 N., R. 4 E. | 172.00 | Madera clay loams, Madera and Gridley loams (undifferentiated). | Hallwood Canal.. | April 17 | June 16 | Oct. 10 | 60 | 117 | 177 | 5 | 1.74 | 7.89 | 9.63 | [6] | ..... | 30 | 37 | ..... | 1.7 | 32 |

[1] Indefinite.

[2] Small loss through outside levee into adjacent slough.

[3] Considerable loss through outside levee into adjacent slough.

[4] Additional loss through outside levee into adjacent slough.

[5] Excessive use caused by porous subsoil.

[6] Considerable loss through and over outside levee into adjacent slough.

[7] Fifty-seven on 78 acres; thirty-five on 151 acres.

crops on lands situated below rice areas by water drained from rice fields at harvest time. In one instance many thousands of dollars worth of beans were destroyed in this way.

There has been considerable criticism in the past from millers of California rice, who claimed that the rice was cut before being fully matured. When the heads of the grain are well turned down the water should be cut out of the laterals. At this stage of maturity most of the kernels are beginning to harden. On the heel or lower part of the head the kernels should be in the dough stage. After the water is removed it is usually two weeks before the soil is sufficiently dry to permit the use of a binder in harvesting the crop.

The experiments at Biggs serve to show the best manner of handling the water on soils in that vicinity, but in sections where the soil contains alkali the usual irrigation programme may have to be modified. On alkali lands near Willows the beneficial effects of applying fresh water and of keeping it circulating through the fields were apparent. Irrigators in that section hope to reclaim the land by frequent drainage and the application of fresh water. This method is also used in portions of San Joaquin Valley on alkali soils, but where pumping from wells is resorted to the cost of water is a limiting factor.

## DUTY OF WATER

Measurements were made in 1916 of the water used on eighteen representative rice fields in Sacramento Valley. This work was done in cooperation with the California State Water Commission and the results are summarized in table 1.[2] Nine of these fields were located on the west side of Sacramento Valley in the vicinities of Willows, Maxwell, and Princeton, and nine on the east side in the vicinities of Biggs, Richvale, Nelson, and Marysville. Ten different soil types were represented. The investigations showed a wide range in the net amount of water used, varying from 4.27 acre-feet per acre to 14.83 acre-feet per acre. The average depth applied to the eighteen fields was 8.23 feet and the average area served per cubic foot per second for the whole season was forty-seven acres. The difference in use was attributed to numerous factors, the more important of which were the character of the soil and subsoil, preparation of land, depth to water table, proximity of lands to sloughs, and manner of handling water. The heads of water used varied considerably in size, owing to the diversity in the size of the fields, but reduced to an acreage basis were fairly uniform. The average head used per acre on the eighteen fields was .052 cubic foot per second before sub-

[2] See also Third Report of the State Water Commission of California.

mergence and .034 during submergence. For a forty-acre field this would amount to 2.08 and 1.36 cubic feet per second, respectively.

On each of three fields where less than five acre-feet per acre was applied, the soil was a black clay adobe, underlain at shallow depths with a non-continuous hardpan with ground water approximately one foot below the surface. These fields were well prepared and the water was carefully handled, little or no water being wasted. Excessive use was found on fields close to sloughs or on land with porous subsoil and with poorly constructed outside levees.

On the Adams field included in table 1, measurements were made of the water used in 1914, 1915, and 1916, the data for these years being given in table 2. This field is located about three miles northwest of Biggs and comprises 39.5 acres in the NE ¼, sec. 34, T. 19 N, R. 2 E. The soil is Stockton clay adobe typical of large areas utilized for rice growing in Butte County.

TABLE 2

RESULTS OF MEASUREMENTS OF THE USE OF WATER ON THE ADAMS RICE FIELD NEAR BIGGS, 1914, 1915, AND 1916

| Year | Date of first irrigation | Date of beginning submergence | Date water was turned off | Number of irrigations prior to submergence | Depth of water used prior to submergence, ft. | Depth of water used during submergence, ft. | Total depth applied, ft. |
|---|---|---|---|---|---|---|---|
| 1914 | April 29 | June 12 | October 12 | 6 | 1.04 | 3.61 | 4.65 |
| 1915 | April 21 | June 9 | October 1 | 7 | 1.37 | 3.50 | 4.87 |
| 1916 | April 13 | June 9 | September 30 | 6 | 1.01 | 3.26 | 4.27 |

Taking the three-year period, the average total depth applied was 4.58 feet and the average length of irrigation season from the time of the first irrigation until water was turned off was 167 days. The field was planted to Wataribune variety, a short-grain rice which comprises the greater part of the acreage of rice in California. Yields of approximately 6000, 4500, and 3900 pounds per acre were obtained in the years 1914, 1915, and 1916, respectively. Especial care was given to this field and the yields were above the average.

The amounts of water used on this field probably represent the minimum use under gravity canals in Butte County and show what can be accomplished with careful handling of water on well-prepared land.

In connection with the above measurements, records of precipitation and evaporation from a free water surface tank were kept by

the Bureau of Plant Industry, U. S. Department of Agriculture, on the Biggs rice field station which adjoins the field.

The amounts of rainfall and evaporation in the periods corresponding to the irrigation season for the years 1914 to 1916, inclusive, are given below:

| Year | Precipitation during irrigation season, feet | Evaporation during irrigation season, feet |
|---|---|---|
| 1914 | 0.21 | 2.91 |
| 1915 | 0.36 | 3.17 |
| 1916 | 0.13 | 3.48 |

Fig. 6.—Rectangular weir and water register used for measuring irrigation water on Adams rice field, near Biggs, California.

Measurements of the water used were made by means of a standard contracted weir and automatic water register shown in figure 6. Average heads of two to five cubic feet per second were used in the initial floodings, while an average flow of .50 to .75 cubic foot per second was continually run during the period of submergence.

It is interesting to compare the irrigation practice and data for rice growing in California with those of the rice sections of Arkansas, Louisiana, and Texas.[3] In those three principal rice-growing states all but 2.5 per cent of the irrigated land in rice is supplied with water by pumping, and wells afford a supply for about one-third of this area. For prairie lands the pumping machinery is generally designed

to provide seven and one-half gallons of water per minute for each acre irrigated, which is equivalent to a flow of one cubic foot per second for sixty acres. For the alluvial lands along the streams ten gallons of water per minute per acre is provided, while thirty-eight to forty gallons per minute per acre is sometimes required if the soil is a loose, sandy loam, with a porous subsoil, and is located near a river. The average length of the irrigation season in the rice sections of Arkansas, Louisiana, and Texas, extending from the time of the first application of water until it is removed to permit harvest, is about eighty-six days.

The fact that more water is required to mature rice in California than in the rice sections of the south is ascribed principally to the difference in climate. The nights are much warmer in the southern states than in California and there is less difference in the daily range of temperature. The number of days that water must be used to mature rice in California is, therefore, much greater than in Arkansas, Louisiana, or Texas. The rainfall during the irrigation season in California is practically negligible, while in the southern states it may amount to ten or twenty inches. The evaporation in California is generally over twice that in the south. Fortier reports that measurements have been made of rainfall, evaporation, and the duty of water for irrigating rice on prairie lands of Louisiana, Texas, and Arkansas for eleven years, during which twenty-one measurements have been made.[4] The averages of these measurements give 15.74 inches of pumped water applied to the land and 17.16 inches of rainfall, and a loss due to evaporation from flooded rice fields of 15.33 inches.

## DRAINAGE

Facilities for drainage are almost as important as for irrigation. The planting as well as the harvesting depends largely upon the condition of the field, and on heavy clay soils which naturally dry out slowly drainage is a most important feature. Poor drainage results in low places remaining wet and not only delays planting, but also impedes the progress of heavy harvesting machinery. Thorough drainage is the only solution for removing alkali salts and for relieving water-logged lands.

In sections where drainage is naturally poor the growing of rice with its heavy application of water tends all the more to increase or intensify the needs of drainage. Any effective means of controlling weeds that now menace the rice industry and conditions that will

[3] U. S. Dept. Agr., Farmers' Bul. 673.

[4] Use of Water in Irrigation, 1 ed., p. 229.

make possible a rotation of crops must depend largely upon adequate drainage. The people of Richvale, realizing the need of lowering the water table which has risen to within a foot of the surface, recently voted $150,000 for drainage. The formation of drainage district No. 833, including lands west of Biggs and Gridley, is a hopeful sign of meeting the problem in that portion of the valley. The opening up of natural water courses and the construction of a comprehensive drainage system in keeping with the flood control work now being undertaken in the Sacramento Valley is likely to have an important bearing upon the future of the rice industry in California.

Fig. 7.—One-fifth acre plat on Rice Experiment Station near Biggs, California, on which submergence was begun thirty days after emergence of plants.

## RESULTS OF EXPERIMENTS IN RICE IRRIGATION

Experiments in rice irrigation were carried on for the years 1914 to 1916, inclusive, in co-operation with the Bureau of Plant Industry, U. S. Department of Agriculture, on the Biggs rice field station. The objects of the investigations were to determine the effect of varying dates of submergence of land, varying depths of submergence of land, the effect of no continuous submergence, as well as the effects of stagnant and slowly-changing water. Attention was also given to fluctuating the depth of water during submergence to determine the effect on the growth of the plant. The tests were made on $\frac{1}{5}$-acre plats (fig. 7) enclosed by well-constructed levees and arranged so that

they could be irrigated and drained separately. The soil is a black clay adobe typical of lands utilized for rice growing in the vicinity of Biggs and Gridley. Results of the experiments are given in table 3.

TABLE 3

EFFECT OF IRRIGATION METHODS AND TREATMENT ON YIELDS AT BIGGS RICE FIELD STATION OF THE BUREAU OF PLANT INDUSTRY, U. S. DEPARTMENT OF AGRICULTURE, 1914, 1915, AND 1916.

| Irrigation treatment | Yield per acre, pounds | | | |
|---|---|---|---|---|
| | 1914 | 1915 | 1916 | Average |
| Beginning submergence fifteen days after emergence of plant | 4510 | 3860 | 3750 | 4040 |
| Beginning submergence thirty days after emergence of plant | **5610** | **4270** | **4020** | 4633 |
| Beginning submergence forty-five days after | | | | |
| Beginning submergence sixty days after emergence of plant | 5410 | 4100 | 3890 | 4466 |
| Submergence maintained two inches deep | 5010 | 4030 | 3620 | 4220 |
| Submergence maintained four inches deep | 5490 | 4290 | 3760 | 4513 |
| Submergence maintained six inches deep | **5670** | **4510** | 3900 | 4693 |
| Submergence maintained eight inches deep | 5220 | 4400 | **3940** | **4520** |
| Slowly changing water | 4790 | 4210 | 3460 | 4153 |
| Stagnant water | 4940 | 3990 | 3800 | 4243 |
| No submergence (soil kept moist by frequent irrigation) | 2440 | 2480 | 2100 | 2340 |
| Fluctuation of depth | 5290 | 4160 | 3690 | 4380 |

Each year the best results were obtained by commencing submergence thirty days after emergence of the plant. In 1914 and 1915 the heaviest yields were secured by maintaining a uniform depth of six inches over the land during submergence, but in 1916 the plat submerged eight inches deep gave the heaviest yield, although the increase in yield only amounted to about 1 per cent over the plat submerged six inches deep. Where no water was held on the land, but the soil was merely kept in a mucky condition, only about one-half of a normal yield was secured and the rice was of poor quality. There was little difference in the yield from the plat which received slowly-changing water and from the plat which had no water removed. No reaction on the growth of the plant was shown from fluctuating the depth. In this experiment a uniform depth of four inches was maintained until "booting" was noticeable. Then the water was lowered to a depth of one and one-half inches. The water was held at this depth until the first heads appeared, when it was applied to a depth of four inches and maintained there until the rice was ready to be drained. This scheme is said to hasten the maturity of the rice in the southern states, but apparently has no appreciable effect here.

In order to determine the maximum and minimum temperatures of water at the various depths of submergence, records were taken daily at 8 A.M., 1 P.M., and 5 P.M. The readings for the shallow depths of water showed higher temperatures during the day and lower temperatures during the night than for the greater depths of submergence. The most uniform temperature was obtained on the plat submerged six inches deep. It is probable the yields are affected to a considerable extent by the daily range of temperature.

## SUMMARY

Approximately 67,000 acres of rice were irrigated in California in 1916, the water supply being obtained principally from Sacramento and Feather rivers. Only about 3700 acres were irrigated by pumping from wells.

Land is prepared for irrigation in contour checks, preparation consisting mainly in making ditches and levees and installing gates. The gates must be wide enough to admit the large heads of water used in the initial floodings.

The irrigation season consists of two periods. Frequent light irrigations with relatively large heads of water are given to germinate the seed and to maintain growth until the plant is four to six inches high, and thereafter the land is continually submerged to a depth of six to eight inches until the rice is matured.

Measurements of the use of water in 1916 on eighteen typical fields in Sacramento Valley showed a range of from 4.27 to 14.83 acre-feet per acre, an average depth applied of 8.23 feet, and an average of forty-seven acres served per cubic foot per second. The heads of water used per acre averaged .052 cubic foot per second before submergence and .034 during submergence. The lowest use was on fields with heavy retentive soil, where the preparation was good and the water carefully handled. The average annual use over a three-year period on a field near Biggs was 4.60 acre-feet per acre. During the three irrigation seasons the average precipitation was 0.23 foot and evaporation 3.19 feet. Irrigation practice and requirements in California differ from those in the Gulf states, due mainly to different climatic conditions.

Adequate drainage is essential to successful rice production. Planting and harvesting are both delayed while the soil remains wet, and the removal of alkali salts and the relief of water-logged lands are dependent upon drainage facilities.

The results of experiments made in 1914 to 1916, inclusive, on black clay adobe soil near Biggs indicated that thirty days after emergence of the plant is the best time for commencing submergence, and that six inches is probably the most advantageous depth of submergence. Very poor yields were secured where no water was held on the land. Fluctuating the depth of water had very little effect on plant growth. More uniform temperatures of the water were found with the greater depths of submergence.

Y.L. 13/5

UNIVERSITY OF CALIFORNIA PUBLICATIONS

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# THE ECONOMICAL IRRIGATION OF ALFALFA IN SACRAMENTO VALLEY

BY

S. H. BECKETT AND R. D. ROBERTSON

(Based on work done under co-operative agreement between the Office of Public Roads and Rural Engineering and the State Engineering Department of California and between the Office of Public Roads and Rural Engineering and the University of California Agricultural Experiment Station.)

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## IRRIGATION INVESTIGATIONS

(In cooperation with Office of Public Roads and Rural Engineering, U. S. Department of Agriculture, and State Engineering Department of California)

FRANK ADAMS — S. H. BECKETT
H. A. WADSWORTH

SAMUEL FORTIER, Chief of Irrigation Investigations, Office of Public Roads and Rural Engineering.
W. F. MCCLURE, State Engineer of California.

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* Died February 12, 1917.

† In co-operation with office of Public Roads and Rural Engineering, U. S. Department of Agriculture.

# THE ECONOMICAL IRRIGATION OF ALFALFA IN SACRAMENTO VALLEY[1]

BY

S. H. BECKETT AND R. D. ROBERTSON

## SUMMARY

### PRACTICAL SUGGESTIONS FOR SACRAMENTO VALLEY ALFALFA GROWERS

#### For Medium Loams

1. Depth of irrigation water required per annum to produce the best yield of alfalfa from medium loam soils in Sacramento Valley ..... 30 to 36 inches, depending on rainfall
2. Desirable depth of irrigation water to apply to alfalfa on medium loam soils at each irrigation ..... 6 to 9 inches, depending on depth of soil
3. Usual number of irrigations per season for alfalfa on medium loam soils in Sacramento Valley where water supply is sufficient ..... 3 to 5
4. Desirable size of border or strip checks for alfalfa on medium loam soils ..... 30 to 50 feet wide by 300 to 600 feet long, depending on grade and soil
5. Desirable grades for border checks on medium loam soils ..... 3 to 6 inches per 100 feet
6. Size of irrigating "head" most common for alfalfa on medium loam soils in border checks of this size in Sacramento Valley ..... 2 to 10 cubic feet per second per check

#### For Very Gravelly or Sandy Soils

7. Depth of irrigation water required per annum with careful practice for alfalfa on very gravelly and sandy soils in Sacramento Valley ..... 48 to 60 inches
8. Desirable depths of irrigation water to apply to alfalfa on very gravelly and sandy soils at each irrigation ..... 3 to 4 inches
9. Desirable number of irrigations for alfalfa on very gravelly soils in Sacramento Valley ..... 2 to 3 per cutting
10. Desirable size of rectangular checks for alfalfa on very gravelly or sandy soils in Sacramento Valley ..... 100 feet by 100 feet
11. Desirable size of irrigating "head" for alfalfa on very gravelly soils in checks of this size ..... 5 to 6 cubic feet per second per check

#### For Heavy Soils

12. Depths of irrigation water required per annum for alfalfa on "heavy" soils in Sacramento Valley (clays and clay loams) ..... 30 to 36 inches
13. Desirable depth of irrigation water to apply to alfalfa on heavy soils at each irrigation ..... 2 to 4 inches
14. Desirable number of irrigations for alfalfa on heavy soils in Sacramento Valley ..... 2 to 3 per cutting
15. Desirable size of border or strip checks for alfalfa on heavy soils ..... 30 to 50 feet wide by 300 to 600 feet long, depending on grade and soil
16. Desirable grades for border checks on heavy soils ..... 1 to 3 inches per 100 feet
17. Desirable size of irrigating "head" for alfalfa on heavy soils in border checks of this size ..... 1 to 4 cubic feet per second

[1] This bulletin presents a brief resumé and summary of a more complete report of the investigations discussed, prepared under the joint authorship of

## INTRODUCTION

From two and one-half to three acre-feet of irrigation water per acre per year is sufficient for the growth of maximum economic yields of alfalfa on the medium loam soils of Sacramento Valley. This is the conclusion drawn from experiments covering a six-year period at the University Farm at Davis, and of observations during one to two years on fifty-four Sacramento Valley alfalfa farms.

In addition to the particular studies from which the above conclusion is drawn, these experiments and observations have been concerned with the duty of water for alfalfa on both the lighter and the heavier soils of the valley, the quantities of water it is desirable to apply to Sacramento Valley alfalfa fields at single irrigations, desirable irrigation "heads" for Sacramento Valley alfalfa fields, the percentage of moisture in the soil necessary to prevent wilting, and the amount of moisture above the wilting percentage that produces the most satisfactory growth.

### EXPERIMENTS AT THE UNIVERSITY FARM AT DAVIS

The duty-of-water experiments conducted at Davis covered the period 1910 to 1915, inclusive. During 1910 and 1911, 8.19 acres in square and contour checks, each 0.20 to 1 acre and averaging 0.28 acre in area, were utilized. From 1912 to 1915 the work was confined to 3.48 acres divided into 15 square checks averaging 0.23 acre each. The soil of these plats is classed by the Bureau of Soils and the University of California Agricultural Experiment Station as Yolo loam.[2]

In addition to check plats which were not irrigated, the various annual depths of water applied were 12, 24, 36, and 48 inches, for the full six years of the experiment, with additional plats receiving annual

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Frank Adams, Ralph D. Robertson, S. H. Beckett, Wells A. Hutchins, and O. W. Israelsen, printed in the fifth biennial report of the California State Department of Engineering, and reprinted as Bulletin No. 3 of that department. The investigations were made as a part of the co-operative irrigation investigations in California conducted under agreement between the Office of Public Roads and Rural Engineering (prior to July 1, 1915, the Office of Experiment Stations) of the United States Department of Agriculture, the State Department of Engineering of California, and the California Agricultural Experiment Station. The work at the University Farm at Davis has been under the local supervision of Professor S. H. Beckett, assisted by O. W. Israelsen and Roy Wray. The work on Sacramento Valley alfalfa farms and on the temporary experimental plat at Willows was done under the immediate supervision of Ralph D. Robertson, assisted chiefly by Wells A. Hutchins. Soil moisture studies were largely made by O. W. Israelsen.

[2] U. S. Dept. of Agr., Bureau of Soils, Reconnoissance Soil Survey of the Sacramento Valley, California.

depths of 18 inches and 60 inches during the last four years of the experiment.

The total depths of 30, 36, 48, and 60 inches were given in individual applications of 7.5 inches, 9 inches, 12 inches, and 15 inches, respectively. In 1910, 1912, and 1913, following winters of low rainfall, the first irrigations were given immediately after the first cuttings, but in 1911, 1914, and 1915, following relatively wet winters, irrigation began after the second cutting.

All of the plats were large enough to represent normal field practice, so the work should be classed as field experiments rather than laboratory experiments. Irrigation water was supplied from a pumping plant on the tract delivering approximately 0.9 cubic foot per second.

Throughout the experiments the practice followed was to irrigate just as soon as possible after removing the crop from the field. Because of the small irrigating head available, slip-joint pipe was used on the larger checks to aid in even distribution.

In the time of cutting, raking, shocking, and hauling the hay standard field practices always were observed. That is to say, the alfalfa usually was cut when one-tenth to one-third in bloom and the hay generally was raked the same day, shocked the following day, and hauled as soon as it was dry enough to be stacked without heating, never being left until the leaves were dry enough to fall off when handled. The curing and removal of the hay from the field required from five to seven days.

The following table summarizes the results of these experiments at Davis over the full six-year period, including the average cost of production and the average profit per acre:

TABLE NO. 1

SUMMARY OF ALFALFA DUTY-OF-WATER INVESTIGATIONS AT DAVIS, 1910–1915

| Number of irrigations | Unit depth each irrigation, in. | Depth of water applied, in. | Yield, tons per acre | | | | | | | Average value of hay per acre at $7 per ton[1] | Average cost of production per acre[2] | Average profit per acre |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 | Average | | | |
| None | .... | .... | 3.85 | 5.94 | 5.52 | 2.75 | 2.89 | 2.35 | 3.88 | $27.16 | $8.73 | $18.43 |
| 2 | 6 | 12 | 4.78 | 7.52 | 6.51 | 4.31 | 5.83 | 4.84 | 5.63 | 39.41 | 15.37 | 24.04 |
| 3 | 6 | 18 | ..... | ..... | 7.02 | 5.69 | 8.02 | 6.46 | 6.80 | 47.60 | 19.35 | 28.25 |
| 4 | 6 | 24 | 6.00 | 8.38 | 8.32 | 6.89 | 9.96 | 7.96 | 7.92 | 55.44 | 23.22 | 32.22 |
| 4 | 7½ | 30 | 7.53 | 9.54 | 9.43 | 7.97 | 11.06 | 8.32 | 8.98 | 62.86 | 26.45 | 36.41 |
| 4 | 9 | 36 | 7.58 | 9.33 | 9.38 | 8.22 | 12.48 | 8.63 | 9.27 | 64.89 | 27.96 | 36.93 |
| 4 | 12 | 48 | 8.45 | 9.52 | 8.63 | 8.83 | 10.62 | 8.05 | 9.02 | 63.14 | 29.10 | 34.04 |
| 4 | 15 | 60 | ..... | ..... | 10.17 | 7.25 | 10.70 | 5.55 | 8.42 | 58.94 | 29.44 | 29.50 |

[1] Market value of hay, 1910, 1911, and 1912, $11 per ton; 1913, $9; 1914, $4; 1915, $8.

[2] Labor of production, including cutting, raking, shocking, and hauling, figured at $2.25 per ton. Water figured at $1.70 per acre-foot. Labor for irrigation figured at 50 cents per acre per irrigation.

Examination of this summary indicates that while both the average maximum yields and the average maximum profits were greatest in the case of annual applications of 36 acre-inches of irrigation water per acre, neither the average increase in yield nor the average increase in profits, with applications at the rate of 36 acre-inches per acre per year, over the average yields and profits with applications at the rate

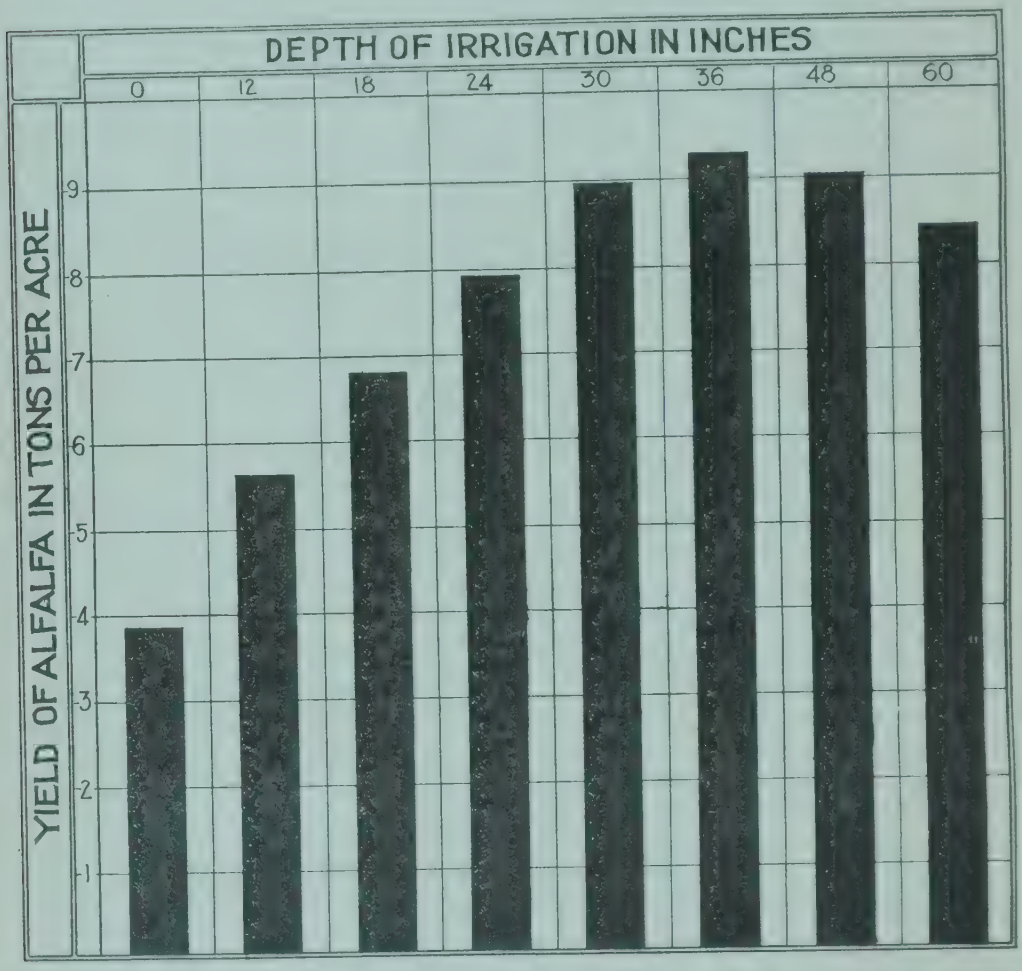


Fig. 1.—Diagram showing results of alfalfa duty of water experiments at University Farm, Davis, 1910 to 1915. Note the maximum yield with an annual application of 36 inches of water. The most economical yields were obtained with annual applications of 30 to 36 inches.

of 30 acre-inches per acre per year, was large enough to be material, with water costing at the rate figured in the Davis experiments. It is plain, however, that to the extent that water costs less than $1.70 per acre-foot the increase in net profits with annual depth of 36 inches over the figures for annual depths of 30 inches would be correspondingly greater, and very much greater if water were paid for at the

flat annual rate of $1.50 or $2 per acre, as was the case in a number of the Sacramento Valley areas included in the general investigation.

The significant fact about the results at Davis is that the increase in yield tends to become negligible above annual depths of 30 to 36 inches, indicating that under conditions at Davis, or similar thereto, a maximum allowance of 36 acre-inches per acre per year is ample. This is further brought out graphically in the accompanying chart (fig. 1).

The most marked change from year to year in the relation of the averages to each other took place in the 60-inch applications. The 1912 yield from the most heavily irrigated plat was more than 10 tons per acre, but the average dropped to 8.42 tons per acre by 1915, and had the investigations been conducted longer this average doubtless would have decreased each year. The 1915 yield was only 5.55 tons per acre, owing to the quantity of rank water grass which had supplanted the alfalfa.

A wide variation in the seasonal rainfall and in the length of the growing season was observed at Davis. Both of these factors seemed to have a decided effect on the yields of hay, as shown by the following table:

TABLE NO. 2

RELATION OF CLIMATE TO YIELDS OF HAY AT DAVIS

| Season | Rainfall | Length of growing season[1] | | Average temperature, ° F. | Number of cuttings | Average yield of hay per acre from all checks |
|---|---|---|---|---|---|---|
| | | Dates | Number of days | | | |
| 1909–1910 | 11.90 | Mar. 22–Oct. 10 | 202 | 57.7 | 6 | 6.36 |
| 1910–1911 | 23.18 | Feb. 27–Oct. 7 | 222 | 58.3 | 6 | 8.37 |
| 1911–1912 | 9.46 | Mar. 3–Oct. 10 | 221 | 57.9 | 6 | 8.12 |
| 1912–1913 | 8.74 | Mar. 4–Sept. 17 | 197 | 58.0 | 5 | 6.49 |
| 1913–1914 | 28.70 | Feb. 6–Oct. 26 | 262 | 60.0 | 6 | 8.94 |
| 1914–1915 | 20.05 | Jan. 23–Oct. 13 | 263 | 59.5 | 6 | 6.52 |
| Average | 17.00 | Feb. 23–Oct. 9 | 228 | 58.6 | | 7.48 |

[1] Period between date of last killing frost in the spring and the date of cutting last crop the following fall.

Immediately following the harvesting of the last crop at Davis, on October 13, 1915, five areas, each containing 100 square feet, were laid off on each plat included in the experiment and the number of plants in each area counted. The probable number of plants per acre was figured from the average of these counts. By field count a good stand of mature alfalfa was found to contain an average of one and one-half plants per square foot. With this as a basis of comparison, the following table was compiled:

TABLE NO. 3

ESTIMATED PER CENT OF ALFALFA STAND REMAINING AT DAVIS AT END OF SIX-YEAR EXPERIMENTAL PERIOD

| Number of plats | Depth of water applied, in. | Number of plants per acre | Per cent of good stand remaining |
|---|---|---|---|
| 17, 30 | .... | 8,625 | 13.2 |
| 18, 29 | 12 | 22,216 | 34.0 |
| 19, 28 | 18 | 30,928 | 47.3 |
| 20, 27 | 24 | 33,977 | 52.0 |
| 21, 26 | 30 | 41,382 | 63.3 |
| 22, 25 | 36 | 39,422 | 60.3 |
| 23, 24 | 48 | 38,333 | 58.7 |
| 31 | 60 | 17,598 | 26.9 |

This shows the effects of the two extremes in the application of water, especially when it is remembered that the observations on the 60-inch application extended over a period of only four years, and in this time the stand, as a result of over-irrigation, was reduced to an estimated average of only 27 per cent of the original.

## INVESTIGATIONS ON SACRAMENTO VALLEY ALFALFA FARMS

In selecting the areas away from Davis to be included in the wider investigation care was taken to include enough fields so that there would be represented the major soil types of the valley, as determined by the soil surveys of the Bureau of Soils and of the University of California Experiment Station, whose soil classifications have been followed in this report; also to give the investigations as wide a geographical distribution as possible, so that the differences in rainfall could be taken into consideration. Accordingly, during the irrigation seasons of 1913 and 1914, between 40 and 50 representative farms were under observation in the neighborhood of Gridley, Los Molinos, Orland, Willows, Woodland, and Dixon, this work being supplemented in 1915 by detailed studies on a single ten-acre tract five miles northeast of Willows, and by general observations and measurements on four other farms.

In every case where the amount of water used was measured the crop yields were ascertained by the most satisfactory means available. In some cases crops either were sold in bulk according to scale weights or baled, making exact weights available. In a few cases stacks were measured or a sufficient number of shocks to be representative of the whole were hauled to nearby scales and the average weight per shock obtained. In a large number of cases the average weight of shocks was ascertained by weighing on the ground.

Table No. 4 below summarizes the results of the measurements on Sacramento Valley farms during 1913 and 1914.

TABLE NO. 4

SUMMARY OF RESULTS OF ALFALFA DUTY-OF-WATER MEASUREMENTS ON FIFTY-FOUR FARMS IN SACRAMENTO VALLEY, 1913 AND 1914

| Name of area | Average rainfall, in. | Number of fields included | Areas covered by observations | Years | Average total depths of water applied, ft. | Average total yields, tons per acre |
|---|---|---|---|---|---|---|
| Gridley | 22.24[1] | 14 | 284.22 | 1913 | 3.31 | 6.19 |
| Los Molinos | 26.11[2] | 12 | 130.40 | 1913–14 | 5.15 | 6.01 |
| Orland | 19.23 | 7 | 214.52 | 1913–14 | 4.66 | 6.26 |
| Willows | 16.55 | 3 | 27.71 | 1914 | 1.83 | 4.82 |
| Woodland | 17.23[3] | 12 | 295.07 | 1913–14 | 2.33 | 6.45 |
| Dixon | 17.23[3] | 6 | 207.17 | 1913 | 2.94 | 6.76 |
| Totals and avgs. | 19.76 | 54 | 1159.09 | | 3.37 | 6.08 |

[1] Biggs record.
[2] Red Bluff record.
[3] Davis record.

If the amount of water used on Sacramento Valley farms, as indicated by the above table, were to be taken as the amount necessary to get maximum economic yield, it is evident that the results at Davis would not be applicable throughout the valley. The amounts of water applied, however, do not necessarily indicate the amounts needed. In many cases much more water was applied than was retained by the soil; and in the case of the compact soils about Willows it was not possible to get into the soil sufficient water to supply the needs of the crop. That the results at Davis are, in general, applicable throughout the valley, with the exception of the results on the highly pervious gravelly loams at Orland and the impervious Tehama clays and clay loams at Willows, was made plain from the approximately 11,000 soil-moisture determinations made on the Sacramento Valley alfalfa farms under observation during three years of the investigations.

At Davis the amounts of water used were strictly under control, and, with the exception of the plat receiving a depth of 60 inches, single irrigations were, as a rule, not greater than the soil would retain, the soil-moisture determinations before and after irrigation showing that an average of 76.4 per cent of the water applied to plats which were given a depth of 6 inches in one irrigation was retained in the upper 6 feet of the soil, and that the plats given 7½, 9, and 12 inches per irrigation, making an average of 9½ inches per application, retained an average of 60.6 per cent in the upper 6 feet of soil and 97.7 per cent in the upper 12 feet. The soil of the experimental irrigation tract at Davis is chiefly a fine sandy loam, relatively uniform, with no

impervious stratum, and with the ground water level below the normal feeding zone of the plant roots. The upper two feet are very uniform, but the third to eighth feet are of fine sandy loam, pocketed at irregular intervals with coarse sand or clay loam. While at Gridley the surface soil of the fields under observation in 1913 does not vary greatly from the soil at Davis, most of it is underlaid with hardpan at depths of from four to six feet, and all of it contained free ground water at six feet or less from the surface. At Los Molinos, while the soil of some of the fields is comparable with that at Davis, being of silty or sandy loam and of relatively uniform depth for at least 12 feet from the surface, some fields have more clay and some are more gravelly than those at Davis. The normal rainfall at Red Bluff, which is the nearest point of observation to Los Molinos, is approximately nine inches greater than at Davis, and in the years 1913 and 1914 it was more than six inches above the average at Davis for the six years covered by the experiments there. An entirely different type of soil is found at Orland, all but one of the fields investigated having been made up largely of gravel. Here, also, water conditions differ considerably from those at Davis, a shortage of water in the late season in 1913 having made it necessary to eliminate one irrigation.

A very wide departure in soil type is encountered at Willows, and, as indicated by the summaries of use on fields under investigation there, it was impossible to get enough water into the soil to satisfy the needs of the crop. While the soils at Woodland are generally comparable with those at Davis, paying for irrigation water on a quantity basis rather than on an acreage basis, as at Gridley, Los Molinos, Orland, and Willows, altered the Woodland practice materially. During the season of 1913 at Woodland, following a winter of low rainfall, the usual practice was to give at least three irrigations, and some farms received water six times, alfalfa bringing good prices that year, and water therefore being applied plentifully. In 1914, however, following a winter of more than normal rainfall, and when the price of alfalfa had dropped to nearly one-third the figure obtainable in 1913, no irrigators watered more than three times, and as a rule only two, with many not watering at all. Observations were made at Dixon during 1913 only. Water used there is obtained from pumping plants and use generally represents what the various irrigators consider to be necessary. While in this regard conditions at Dixon are similar to those which governed the experiments at Davis, the soil is considerably heavier than at Davis, and takes water much less freely.

*Gridley.*—Analyzing the results obtained at Gridley, it was found that a maximum yield of 9.38 tons was obtained from a field which

received a total annual depth of irrigation water of 31.6 inches, but that the next nearest yield was only 7.28 tons per acre, obtained on a field which received 34 inches of water for the season. Eight out of the fourteen fields studied at Gridley received greater annual depths of irrigation water than 34 inches, but on three of these the yield fell below five tons, on four below six tons per acre, and on seven below seven tons. In other words, after eliminating the single field that had the excessive yield of 9.38 tons per acre, it was found that the point beyond which it did not pay to add to the depths applied corresponds substantially with the points established in the Davis experiments, namely, between 30 and 36 inches. The seasonal rainfall at Gridley preceding the heaviest of these yields was 13.9 inches.

*Los Molinos.*—Analyzing the results obtained at Los Molinos for the seasons 1913 and 1914, it is found that a maximum yield of 8.31 tons per acre was obtained with a total annual application of 47.4 inches, following an average rainfall for the two seasons of approximately 24.4 inches. To what extent, if at all, excessive use here reduced yields by soil leaching can only be conjectured. Seven of the 11 fields under observation received more irrigation water than the field of maximum yield, the maximum application being 84 acre-inches per acre. Of these seven fields, however, one yielded less than four and one-half tons per acre, four below six tons per acre, and six below seven tons per acre. At Los Molinos it is to be noted that both the maximum and the majority of applications were considerably in excess of the applications at Davis, but, as pointed out in the discussion of soil-moisture determinations in this area, the soils of the Los Molinos fields are highly permeable and the use of water was wasteful. Studies of the underground distribution of the irrigation water applied showed that beyond a doubt large quantities passed below a depth of six feet, single applications amounting, in numerous cases, to between 20 and 30 inches.

*Orland.*—Averages for eight fields at Orland, where the soil is prevailingly gravelly, gave a maximum of 6.77 tons per acre, with a total annual application of 24.6 inches after an average seasonal rainfall of 19.2 inches. The maximum yield at Orland was obtained on the field that received the least water, the yield from two of the seven remaining fields falling below five tons, and that from five falling below six tons. Of the whole eight fields water was applied in excess of 80 inches on two fields, in excess of 55 inches on three fields, and in excess of 45 inches on five fields.

*Willows.*—With complete results available for only one year and from only three fields at Willows, but with these results verified by

special studies in 1915, it is evident that the results are in no way comparable with the results at Davis, this being due to the "tightness" of the soil of the Willows fields and the impossibility of getting irrigation water into it in amounts sufficient to satisfy the plants. A maximum yield of only 5.39 tons was obtained at Willows with an application of 23.6 inches in addition to the seasonal rainfall of approximately 28.7 inches for the preceding winter. Results at Willows indicate plainly that the soil-moisture needs of alfalfa, on the soils that hold moisture so tenaciously as do those at Willows, are in excess of the maximum applications found in 1914. Further, it is plain from the special studies in 1915 that to irrigate adequately the silty clay loams and the clay adobes of the Willows area water must be applied frequently and in small quantities, and at no time following the winter rainfall must the soil be allowed to dry out. The amount of water used on these Tehama clay soils is sure to increase as improvement in their physical condition, due to cropping and cultivation, makes them more pervious to water.

*Woodland.*—Averages for the 12 fields at Woodland, for which full records are available, show a maximum yield of 8.81 tons per acre with a use of water of 29.7 inches in addition to an average seasonal rainfall of 18.3 inches. Three fields, which received depths of 23.5, 33.1, and 43.7 inches, gave respective yields of 7.60, 7.87, and 8.04 tons per acre. Taking seven fields for which the yields were most nearly equal, the range of variation being slightly over two tons and the average yield being 6.93 tons per acre, the average use was found to be a depth of 30.7 inches. Thus at Woodland it is found also that the usual maximum use, taking an average of one wet and one dry season, does not depart widely from that found most satisfactory at Davis; also that the maximum average yield for one field during the two years of record was obtained with slightly less than 30 inches.

*Dixon.*—Here the largest yield in the single year of observation was 9.97 tons per acre with a total depth of irrigation of 37.7 inches, in addition to a seasonal rainfall of 7.31 inches. The average use for six fields, from which complete records are available, was 35.3 inches, or again in close agreement with the Davis experiments.

The allowance necessary to be made for difference in local soil conditions and irrigation practice is, it is believed, fully established by the comparisons made above. In general, as already indicated, the statement is justified that the six-year record for Davis is applicable throughout the valley except to the very open soils such as those around Orland, and the silty clays and clay adobes found in these investigations in the neighborhood of Willows, but also existing else-

where in considerable areas. The average for Willows indicates, as already pointed out, that total irrigations of less than 24 inches per season are insufficient for satisfactory yields, while the results at Orland indicate that applications averaging in excess of 48 inches per year, while sometimes difficult to overcome on the very gravelly soils, do not give corresponding increases in tonnage. The average use at Woodland, which was below that at either Dixon or Gridley, was plainly a result of paying for irrigation water on a quantity rather than on a flat acreage basis. Finally, the average at Gridley illustrates what may be expected on the open loam soils underlaid with hardpan or ground water.

## INVESTIGATIONS ON EXPERIMENTAL TRACT AT WILLOWS

Investigations on alfalfa farms near Willows in 1913 and 1914 disclosed a relatively small use of irrigation water and correspondingly low yields of hay. Soil borings soon made it evident that irrigation water was not penetrating sufficiently deeply into the soil to meet the needs of the alfalfa plants. In some cases irrigators who considered that they were applying an ample quantity of water were in fact wetting only the upper ten or twelve inches of soil, whereas normally at least the upper four to six feet should have had water.

The heavy soils encountered in the investigations around Willows are classified in the soil survey as Tehama clay and clay loam.[3] These soils are all of compact structure and inclined to be refractory, very sticky when wet, and subject to hard baking when drying.

As indicated in table No. 4 above, the average use of water on three farms at Willows in 1914 was 1.83 acre-feet per acre, and the average yield on six farms there in 1914 was only 4.82 tons per acre. In no single case was more than 1.97 acre-feet of water per acre applied per season, and none of the measured yields of alfalfa exceeded 5.39 tons per acre.

For the purpose of ascertaining if more frequent irrigations would improve conditions on these heavy soils, a field of 8.75 acres about five miles northeast of Willows was utilized for experimental purposes during the season of 1915. This field was already in alfalfa and carried one of the best stands to be found in the immediate neighborhood. The field was divided into twenty-one border checks, 60 feet wide by 300 feet long, having an average grade of four inches per one hundred feet and an average area per check of 0.42 acre.

[3] U. S. Dept. Agr., Bureau of Soils, Reconnoissance Soil Survey of Sacramento Valley, California.

The soil in this field, which is classed as a Tehama clay loam, is grayish in color and of compact structure and refractory nature. When wet it is sticky, and upon drying becomes very hard, but does not check or crack. It is free from both hardpan and gravel and little difference is noticeable between the soil and subsoil. This type of soil was selected because the soil survey maps indicate the presence of about 45,000 acres of it in the Sacramento Valley, very largely east of Willows in the area surrounding this field.

The amount of water used on each of the plats during the season was two acre-feet per acre, an average irrigation head of 2.82 cubic feet per second being generally divided between two checks, although various other sizes of heads were tried. One-third of the twelve checks under observation were irrigated with a depth of six inches, once for each cutting except the last, one-third received two three-inch irrigations between cuttings applied just before and just after the crop was removed, and one-third received three two-inch irrigations, at intervals of about 12 days. All of the water entering the field was measured by a 2½-foot rectangular weir and automatic register.

For the purpose of increasing, if possible, the perviousness of the soil to water, two checks were treated with ground limestone at the beginning of the season at the rate of four tons per acre. It was not expected that these checks would show much change the first year, and they did not. The largest annual yield of alfalfa, 5.07 tons per acre, was obtained from the checks receiving three two-inch irrigations per cutting, an increase of 18 per cent over the lowest yields, 4.42 tons per acre, being secured from the checks that received two three-inch irrigations per cutting, and lowest yield, 4.29 tons per acre, coming from the checks irrigated with one six-inch irrigation per cutting.

While the above increases of yield indicate the desirability of more than one irrigation per cutting, the differences in the one season of investigations were not great. It was evident to those in the field, however, that the more frequent the application of water the better the moisture condition of the soil. Borings for soil-moisture determinations were difficult, except immediately after irrigations, and even then difficulty was encountered below the first foot of soil. Including the 12 plats, a total of 3408 moisture determinations were made before and after irrigations, and while the chief value of these is in the larger understanding they give of the character of these compact soils, especially with reference to the permeability to irrigation water they substantiate, to the extent reasonably to be expected, the better results due from the more frequent applications of irrigation water.

In order to gain an idea of the root development of the alfalfa in this field, a hole about six feet square and three feet deep was excavated. This also afforded a good view of the cross-section of the soil formation. The roots of the plants were carefully removed. It was found that the taproots of the alfalfa were not over one-half inch in diameter and did not extend below a depth of three feet. The main mass of the roots was concentrated in the upper two feet of soil. The fact that the greater part of the alfalfa plants in this particular field are shallow-rooted is attributed largely to the compact structure of the soil, making moisture penetration difficult.

After removing the soil for root examination some rather surprising results were found in tests made by filling the hole from which they came with water and noting the time required for downward and lateral percolation. Twenty-four hours after the hole had been filled to a depth of three feet there remained in the hole two feet of water. Two weeks later there still remained one foot. Holes two inches in diameter and four feet deep bored 12 inches away from the large test hole showed no lateral percolation. In holes bored six inches from the test hole a slight amount of water had seeped through after 12 hours. Later another hole was excavated in a different part of the field and similar trials made, practically the same results being secured as in the first test. These tests serve to show the impermeability and peculiar physical conditions of the soil represented in this field.

## QUANTITIES OF WATER TO APPLY TO SACRAMENTO VALLEY ALFALFA FIELDS AT SINGLE IRRIGATIONS AS DETERMINED BY THE CAPACITY OF THE DIFFERENT SOILS TO RETAIN WATER

At the outset of the investigations, one of the important practical questions presented was, How much irrigation water applied at one time, and added to that already present in the soil at the time of irrigation, would the various soils of Sacramento Valley retain? While no particular effort was made in the investigations to ascertain how much irrigation water the various soils encountered would hold during the actual process of irrigation,[4] it was desired to ascertain how much would be retained after any surplus should pass through the soil; or, in other words, how much of the water applied would be retained against gravity. As the amount retained would depend largely upon the size of the soil particles, it was deemed best to have mechanical analyses made of the soil from a number of the fields under observation. This was done by the Division of Soil Technology of the

[4] This was however, indirectly ascertained through "pore space" determinations.

College of Agriculture of the University of California. Further, as the quantity of water soils will absorb and the rapidity with which it is absorbed depend to a considerable degree on the compactness of the soil, and, in order to determine what portion of the water applied in irrigation was retained by the soil, it was necessary to ascertain the volume weight of the soils "in place." This was done partly by standard laboratory methods, but chiefly by a special field method devised in the course of the investigations, and found to conform within satisfactory limits to other methods commonly used by investigators in more precise experiments.[5]

The principal work in tracing the underground distribution of the irrigation water was done on fifteen fields—two at Gridley, four at Los Molinos, one at Orland, two at Willows, five at Woodland, and one at Dixon. With the possible exception of one of the fields at Woodland and the two fields at Willows, the soil sampling indicated that the capacity of the soil to retain water, assuming sufficient underdrainage to carry off the free water in the soil, was satisfied. A careful analysis of the results of the soil sampling and moisture determinations brings out the following facts that should be of practical interest to irrigators.

1. Four times as much water was applied, on the average, to the silt loam soils with fine sandy loam subsoils as it was possible to apply, on the average, to the compact clay soils of the experimental tract at Willows, and more than three times as much as was applied to the clay soils of two of the fields at Willows.

2. Only about one-third of the water applied to the silt loam soils, as represented by five fields, was retained for the use of the alfalfa plants in the upper six feet of the soil, where the principal root development is located.

3. In the case of none of the 15 fields under observation did the amount of water retained per irrigation in the upper six feet of soil exceed 8.20 acre-inches per acre,[6] and in only two cases of the 15 did it exceed six acre-inches.

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[5] The method followed consisted in weighing all of the soil taken from holes carefully bored with a two-inch posthole type soil auger and then ascertaining the volume of this soil as it was "in place" by the use of a thin rubber tube inserted in the hole and filled with a known quantity of water. This method was "checked" against the laboratory method by use of the Bowman soil compactor, the iron cylinder, and the paraffin methods as applied to soils in place in a series of experiments conducted by Mr. O. W. Israelsen of this investigation and Professor Charles F. Shaw of the Division of Soil Technology of the College of Agriculture of the University of California.

[6] Clay loam strata at depths varying from eight to ten feet caused partial waterlogging in overlying soil, hence the figure 8.20 is unusually high. All of the water in this soil was not retained against gravity.

4. In only two cases out of ten in connection with the clay soils did the water that was absorbed by the upper six feet of soil reach four acre-inches per acre, in only three cases did it exceed three acre-inches per acre, and in four cases it was less than two acre-inches per acre.

5. The average quantities of water retained per acre-foot of soil per irrigation were 0.92 acre-inch for the silt loams with fine sandy loam subsoils, 0.71 acre-inch for the silt loams without fine sandy loam subsoils, 0.58 acre-inch for the clay loams, and 0.37 acre-inch for the clays, not including the experimental tract at Willows, in every case less than one acre-inch per acre-foot of soil.

6. The maximum average quantities of water retained by the upper six feet of soil per acre-foot per irrigation were 1.02 acre-inches for the silt loams with fine sandy loam subsoils, 0.75 acre-inch[7] for the silt loams without fine sandy loam subsoils, 0.78 acre-inch for the clay loams, and 0.49 acre-inch for the clays.

7. Counting only the fields in which the full capacity of the soils to retain water against gravity was satisfied, i.e., all of the fields having loam soils except one field at Woodland, the average water retained per irrigation in the upper six feet of soil was 4.31 acre-inches per acre, or only 32.6 per cent of the average individual applications, and only 0.72 acre-inch per acre-foot of soil.

8. Assuming that in every case the surface foot of soil received at each irrigation sufficient water to satisfy its full capacity to retain water against gravity, it is found from the detailed data at hand that the average for the 18 fields, including the experimental tract at Willows, was 1.23 acre-inches per acre, and that the averages for the different soil types were 1.08 acre-inches per acre for the silt loams, 1.35 acre-inches per acre for the clay loams, and 1.35 acre-inches per acre for the clays. Therefore, in the case of the typical silt loam soils of the Sacramento Valley, assuming one irrigation per cutting, single applications of irrigation water exceeding a depth of one to one and one-half inches per foot in depth of the soil it is necessary to moisten, accomplish no useful purpose. The typical clay loams and clays of Sacramento Valley, in their normal condition of moisture, will absorb and hold against gravity as much as one and one-fourth to one and three-fourths inches in depth of irrigation water per foot of soil it is necessary to moisten; however, that amount of water will not be absorbed by these soils unless it is applied very slowly.[8]

[7] Not counting the field on which 8.20 acre-inches per acre were retained because of abnormal conditions previously referred to.

[8] It is of interest here to note that with the surface foot of soil filled to its capacity to retain water against gravity the percentages of the pore space of the soil filled were as follows: for the silty loam soils, from 37 to 55 and averaging

It seems evident from the figures given above that there is much ground for improvement in the matter of the quantity of water to apply to the alfalfa fields of Sacramento Valley at single irrigations. Had it been feasible to carry the soil-moisture determinations to a greater depth than six feet, the extent of the waste resulting from the large single applications would be still clearer. The data obtained are, however, sufficient to show clearly that the prevailing practice on Sacramento Valley alfalfa fields is to apply far more water at single irrigations than the more open soils have capacity to retain and than the more compact clay soils absorb under methods of application followed.

A significant comparison can be made between the amounts of water retained by the soil in the case of the 15 typical Sacramento Valley alfalfa farms and the amounts retained in the case of six of the plats on the experimental tract at Davis, where the applications of water were under definite control. The average depth of water applied per irrigation to these six plats was 7.75 inches and the average quantity retained in the upper six feet of soil in the years 1913, 1914, and 1915 was 4.59 acre-inches per acre, or 66.8 per cent of the amount applied. On some of these plats, however, the borings for soil-moisture determinations were made to a depth of 12 feet, and it was found that within this depth practically all of the water applied was retained for the benefit of the plants. The average amount of water added by irrigation to the surface foot of soil in the Davis experiments was 1.45 acre-inches per acre. In other words, from the standpoint merely of the capacity of such deep loam soil as that at Davis to retain irrigation water against gravity, and assuming that the lower depths will "take up" as much water as the surface foot, the application once per cutting of one and one-half acre-inches of water per acre-foot, of soil it is desired to moisten, is not excessive.

## DESIRABLE IRRIGATION "HEADS" FOR SACRAMENTO VALLEY ALFALFA FIELDS

In any investigation of the proper duty of water the size of the irrigation heads used and its relation to the type of soil irrigated, the method of irrigation followed, and the size and slope of the individual areas watered with a single head are always important. Fields may be evenly surfaced and levees perfectly made and proportioned, and yet the result will be excessive waste or inadequate absorption if the

45.5; for the clay loam soils, from 51 to 71 and averaging 62.2; for the clay soils, from 57 to 74 and averaging 65.5; and for all of the fields combined, 54.5.

stream of water turned into each check is either too large or too small. The discussion as to what became of the water applied on a number of Sacramento Valley alfalfa fields, already presented, showed that where large quantities were applied to the open loam soils at single irrigations much of the water passed below the principal rooting zones of the alfalfa plants, and that the usual practice followed in irrigating the clay soils failed to accomplish sufficient penetration by the water. The stabilizing of the irrigation heads used in Sacramento Valley, with direct reference to the size of checks and the character of the soil,

Fig. 2.—A thoroughly prepared alfalfa field ready for final harrowing and seeding. These checks do not exceed 500 feet in length or 40 feet in width.

is obviously one of the very important irrigation problems of the valley. Quite extensive experiments and observations will be necessary for furnishing a satisfactory basis for fully understanding this problem, but the collection of some information bearing on the question was accomplished during the investigations in 1913 and 1914. This information was obtained from twenty-five fields—three at Gridley, two at Los Molinos, five at Orland, two at Willows, nine at Woodland, three at Davis, and one at Dixon. Five classes of soil were covered—gravelly loams, three fields; sandy loams, four fields; silt loams, nine fields; clay loams, six fields; and clays, five fields. Observations of the underground distribution of the water applied were made in connection with ten of the fields.

From an investigation of the data gathered in these investigations, it is evident that the most desirable head of water to use on any given soil can not be adequately determined by comparing use on different fields. The present general practice in Sacramento Valley, expressed in cubic feet per second per acre, is, however, satisfactorily indicated from the average figures obtained, namely, 23 for gravelly loams, 10.9 for sandy loams, 8.8 for silt loams, 7.3 for clay loams, and 3.2 for clays. The difficulty of irrigating porous soils with small heads and of irrigating clay soils with large heads is well recognized among irrigators, even if the most satisfactory relationships have not been worked out in detail.

While a comparison of the rates of application on the different fields as given above fails to disclose the best size of head to use, a comparison of the relation between irrigation heads and depths of application on single fields makes it plain that in many cases either the head should be increased or, even better, the area of the checks reduced.

Summarizing the rates and depths of application at different irrigations of five individual fields, it was found, with minor exceptions, that in each instance, where the soil was sandy loam or silt loam, the depth of water applied increased as the rate of application decreased. In one case, due to the use of a relatively small head, a depth of 3.03 feet of irrigation water was used before the surface of the field was flooded. In four cases more than 2 feet in depth was applied per irrigation, and in fourteen cases out of twenty-seven the depth of application at each irrigation exceeded one foot.

In order to carry this matter further, measurements of the amount of water required to cover a one-acre check, having a slope of 3½ inches per one hundred feet, when applied at different rates were made at Davis. The data obtained were as follows:

| Rate of application, cu. ft. per sec. per acre | Depth of water required, ft. |
|---|---|
| 4.6 | 2.75 |
| 10.1 | 1.86 |
| 13.5 | 1.16 |
| 15.3 | 0.84 |
| 17.8 | 0.69 |

Until the proper relation between irrigating heads and size of checks is satisfactorily worked out in Sacramento Valley soil, there is sure to be, there as well as elsewhere, much difference of opinion as to whether small checks and correspondingly small irrigation heads or large checks and correspondingly large irrigation heads should

prevail in the irrigation of alfalfa. Those who favor large checks and large heads base their preference chiefly on the greater rapidity with which irrigation can be accomplished with large heads, and also on the assumed lesser cost of preparing the land for irrigation. As a rule, where large heads are available they are used, and in some cases, as pointed out in connection with the heavy soils, especially the "water-tight" soils found in some portions of the Willows area, the heads were plainly larger than they should be. In the case of individual pumping plants, which rarely discharge more than one or two cubic feet per second, checks necessarily are small. That waste of land goes with the large field ditches necessary in carrying large heads, and also that extravagant notions of use, and a greater waste when breaks occur with large heads, are sound arguments in favor of small heads, can not be doubted. Thoughtful consideration by irrigators and intelligent advice by public agencies in time will work out that relationship which best will serve both irrigators and the public. In the meantime, it is very clear that irrigators should bear in mind the fact that the irrigation head should not be a constant quantity, but should be varied, where practicable, with the different soils found on nearly every farm.

Dimensions and grades of alfalfa checks vary somewhat in the six sections of Sacramento Valley studied. Some square and rectangular checks are used in each section, but border or "strip" checks are most common, except on gravelly soils at Orland, where the most satisfactory check probably is one about 100 feet square, containing a little under one-fourth acre, and with each check having direct access to a field lateral to do away with carrying water to one check over another. The border checks range from 30 to 120 feet in width and from 60 to 1750 feet in length, the most usual width being from 30 to 50 feet and the most usual length from 400 to 700 feet. The grades of border checks range from 0.6 to 12 inches per 100 feet and average 3.6 inches per 100 feet.

## DESIRABLE MOISTURE PERCENTAGES FOR ALFALFA IN SACRAMENTO VALLEY SOILS AND THE EFFECT OF VARIATION IN SOIL MOISTURE ON RATES OF ALFALFA GROWTH

In interpreting the results of the large number of soil-moisture determinations made at Davis and on Sacramento Valley alfalfa farms from 1913 to 1915, account has been taken of the moisture percentages found as related to the percentages at which the plants would wilt, and

also of the effect of the variation in those percentages on the growth of the alfalfa. The percentages at which the plants wilt, or the "wilting coefficients," have been computed on the basis of the experiments of Messrs. Briggs and Shantz of the Bureau of Plant Industry of the United States Department of Agriculture.[9] As indicated by these experiments, the wilting percentage may be stated to be the point below which moisture in the soil ceases to be available to the plants, or, at least, below which it is obtained only with great difficulty. Due largely to the difference in the size of the soil particles, plants will wilt in clay soils when there is still an amount of moisture that in sandy soils would be ample for all plant requirements.

Determination of the wilting percentage of the soil was made for eight of the experimental plats at Davis, six of the experimental plats at Willows, and eleven of the Sacramento Valley alfalfa farms. Grouping the figures obtained, by soils, the average wilting percentages found were as follows: silt loams with fine sandy loam subsoils, 10.65; other silt loams, 13.12; clay loams, 14.21; clays, 13.06.

In other words, it is necessary that at least the percentages of moisture indicated shall be present in these soils at all times in the growing season if the plants are to be kept from wilting.

It must be noted, however, that in addition to these percentages of soil moisture that are necessary to prevent wilting, additional quantities must be present in order to produce satisfactory growth. Such additional amounts constitute the "available" moisture present in the soil.

Obviously, it is impossible to disregard the numerous soil and climatic factors other than soil moisture that affect the yields of alfalfa, and then to expect the yields and moisture percentages to be consistent throughout. However, by grouping the yields above eight tons per acre, from six tons to eight tons per acre, and below six tons per acre, it is possible to approximate the best or "optimum" percentage of available moisture over and above the amount necessary in each soil to prevent wilting.

Assuming the yields over six tons per acre to have been produced on soil having at least as much as the "optimum" percentage of available moisture, the data indicate that the "optimum" for Sacramento

[9] U. S. Dept. Agr., Bureau of Plant Industry Bulletin 230. The wilting percentages, or "wilting coefficients," for the Sacramento Valley soils are based on the "moisture equivalents" of those soils, as determined in the laboratory of the Division of Soil Technology of the College of Agriculture of the University of California in the course of these investigations. It might be noted here that the moisture equivalents are the percentages of moisture retained in the soil after the soil has been subjected to a centrifugal force equal to 1000 times the force of gravity.

Valley conditions ranges between about 3 per cent and about 7 per cent and averages about 5 per cent above the wilting percentage.

For one of the fields at Los Molinos and one of the plats at Davis, on both of which an excess of irrigation water was applied, the average available percentage was 8.91, or well above the "optimum". On the other hand, the average percentage of available moisture on six experimental plats at Willows, four plats at Davis, one field at Woodland, and one field at Willows, for which either the application or the absorption of irrigation water was plainly deficient, was only 1.02, or well below the "optimum".

The percentages of moisture that must be present in the various Sacramento Valley soils dealt with in order to prevent wilting are believed to be of value because they indicate to Sacramento Valley irrigators not only the difference between the clay or "heavy" soils and the loams and sandy soils as regards the amount of soil moisture needed to prevent wilting, but also that for all of the soils the wilting percentage is higher than farmers usually suppose.

If one could assume an absolutely dry soil it might be convenient for irrigators to know that, as disclosed in the investigations, the amount of water necessary to supply the wilting percentage is approximately the equivalent of about one and two-thirds inches of rainfall per foot of depth of soil in which the crop is growing, in the case of the silt loams with fine sandy loam subsoils, of about two inches in the case of the other silt loams, of about two and one-fourth inches in the case of the clay loams, and of two and three-fourths inches or more in the case of clays such as those found at Willows.[10]

In other words, with an absolutely dry silt loam soil eight feet deep the first 16 inches of irrigation water would no more than supply the amount of moisture necessary to keep deep-rooting plants from wilting; or, expressed still differently, with such a soil wholly devoid of moisture, the equivalent of a rainfall of two inches for each one foot depth of soil the crop utilizes would need to be supplied before the roots of the crop could begin to utilize the moisture.

Fortunately an absolutely dry soil is rarely found in the Sacramento Valley, even at the end of the summer season, and except in very dry years the soils of the valley are not likely to begin the spring growing-season with less soil moisture than the wilting percentage.

[10] The soil-moisture studies in connection with the clay soils at Willows disclosed lower wilting percentages and lower capacities to absorb irrigation water than were to have been expected. It is not intended to discuss this technical phase of the subject in the present report, and conclusions for all Sacramento Valley clay soils can not and should not be drawn from the experience reported herein with the Tehama clays under investigation at Willows.

The figures given should make it very plain that soils into which irrigation water percolates with difficulty should be watched very carefully at depths from four to six feet below the surface. The experience of the field investigators at Willows indicated that this care is especially necessary even early in the summer in order to insure that an adequate irrigation supply shall replace the moisture absorbed from the winter rainfall after that has been utilized.[11]

[11] What is said in the text regarding desirable moisture percentages for Sacramento Valley soils growing alfalfa considers the matter only from the standpoint of the total annual yields of hay. It is obvious, however, that the annual yields are results of conditions that vary from day to day and from week to week. For instance, considering the moisture factor only, annual differences in yield were results of the daily and weekly differences due to daily and weekly variations in soil moisture. The data collected have been studied with reference to the effect of these changing moisture percentages on the seasonal rates of growth, but as no data were collected to indicate daily or even weekly variations in rates of growth, making it necessary to rely on average rates of growth between cuttings, such deductions as were suggested in the study have not seemed sufficiently conclusive to warrant their presentation. It is, however, possible to say that where the moisture percentage was found to fall below the wilting point there was also found a definite falling off in the rate of alfalfa growth.

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# CONTROL OF THE POCKET GOPHER IN CALIFORNIA

## I. Natural History of the Pocket Gopher; Various Methods of Control

By JOSEPH DIXON

*Contribution from the Museum of Vertebrate Zoology University of California*

## II. A Method of Poisoning Pocket Gophers

By E. RALPH DE ONG

*Agricultural Experiment Station, University of California*

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† In co-operation with office of Public Roads and Rural Engineering, U. S. Department of Agriculture.

# I. NATURAL HISTORY OF THE POCKET GOPHER VARIOUS METHODS OF CONTROL

By JOSEPH DIXON

Contribution from the Museum of Vertebrate Zoology, University of California

The damage done by the pocket gopher in the United States has been estimated at over twelve million dollars per year.[1] California is one of the chief losers. The depredations by the gopher are locally numerous, involve nearly the entire state, and go on all the year. The losses, taken one by one, may be trivial, but in the aggregate are considerable. These features all taken into account lead to the belief that more damage is done by the gopher in this state than by any other one animal, not excepting the ground squirrel or the coyote.

## NATURE OF THE POCKET GOPHER

The pocket gopher is a small, chunky, short-legged, burrowing rodent, with large protruding front teeth, fur-lined cheek pouches, which are used to carry food, not dirt, and which open outside the mouth, small ears and eyes, and short tail, often naked at the tip. The gopher averages smaller than either the common house rat or the wood or "trade" rat, but there are often great differences in size, especially between the sexes. Because most of the gopher's work is done in the dark, either underground or at night, the disastrous results are better known to most people than is the animal itself.

The Pocket Gopher Compared with Animals Sometimes Mistaken for it

| | Tail | Fur | External cheek pouches | Front teeth |
|---|---|---|---|---|
| **Gopher** | short, 2 to 3 in., often naked at tip | harsh | always present | large, protruding |
| **Mole** | short, 1 to 1¾ in. | velvety | none | small |
| **Meadow mouse** | short, 1 to 1⅔ in. | harsh | none | small |
| **Kangaroo rat** | long, 6 to 10 in. | silky | always present | small |

The mistake most often made is that of confusing the work of the mole with that of the gopher. These two animals, however, are totally different. The mole is not a rodent (gnawer) at all. It lives on animal matter (worms, grubs, and insects) and not vegetable matter. A mole may occasionally be caught in a gopher run; but the gopher

[1] U. S. Dept. Agric., Farmers Bulletin No. 335 (1908), p. 19.

is the real cause of such damage as eating potatoes and cutting off roots, which is sometimes attributed to the mole. The mole crowds along just beneath the surface in loose soil, leaving ridges in which numerous cracks are visible. The gopher *digs* tunnels, and the sides of these are left clean cut. During dry weather, especially, the mole often burrows deeply and throws up mounds, but these show no trace of an opening, while those of the gopher do. Many moles have been caught for museum specimens by setting Macabee gopher traps carefully in the main runs of moles (see p. 9, Special Sets).

## BREEDING HABITS

The data recorded with the 2100 specimens of gophers, collected throughout the state, which are now in the University of California Museum of Vertebrate Zoology, form the main basis for the following breeding notes. Gophers have from three to twelve young in a litter. The smallest number of embryos (unborn young) found in females were three and four, the greatest eleven and twelve, while the average in twenty-eight females from many parts of the state was 5.8. There is evidence to indicate that two litters are frequently raised in a season where food is plentiful, as in alfalfa fields.

Out of eighteen female gophers taken near San Bernardino, November 7 and 8, 1916, four contained small embryos and all but two of the remainder were ready to breed. The breeding season can perhaps best be gauged by the period of growth of the alfilaria, or "filaree." This and malva, among all our native plants, seem to be the gopher's favorite food. The alfilaria is one of the earliest plants to start after the first fall rains, and the resulting nutritious food supply seems to start the gophers breeding. The nest is underground, and usually placed beneath a stump, rock pile, brush pile, or some other such surface protection as will discourage badgers or coyotes from digging. The young remain in it for several weeks after birth and do not leave until they are nearly half grown, when they are able to forage for themselves. In plowing an abandoned field in San Diego County in the middle of January, 1911, the writer uncovered at the bottom of the furrow near a willow stump a nest containing a mother gopher and four hairless, helpless young, barely able to crawl.

The following dates show the approximate time of year when the main crop of young begin leaving the nest, though young may also be found foraging for themselves much earlier or later than these dates: southern California, March 30; San Joaquin and Sacramento

valleys, April 1; Owens Valley, April 15; foothills of Sierra Nevada, April 30; northwest coast region, May 15.

### WHEN TO TRAP AND POISON

Obviously, the time to combat gophers most successfully is *before* the young make their appearance in the spring. Poisoning is very effective, but harder to carry on than trapping in the dry season, especially during August, September, and October, when the supply of green food is scarcest. Trapping is most easily carried on soon after the green vegetation starts in the early winter or spring, for the gophers are then most active. The wise old males which usually cause the trapper the most trouble, seem to lose their instinctive caution during the mating season and often blunder blindly into traps which they would never enter at other times. Every female caught at this time, before the young are born, means the destruction of from *four* to *twelve* gophers for the current season.

### METHODS OF DESTRUCTION

The five most effective methods of destroying gophers are: (1) poisoning with strychnine; (2) trapping; (3) fumigation with carbon bisulphide; (4) flooding; (5) for permanent relief, encouragement and protection of the gopher's natural enemies, especially the barn owl and gopher snake.

The solution of the gopher problem lies in a combination of two or more of the above methods, rather than in any one of them. Where a large acreage is to be treated, poisoning with strychnine will be found effective in reducing the pest. Traps are *safe,* can be used at any time, and are effective in the hands of a man who is not afraid to dig and who uses care in setting and in placing his traps. Traps are especially adapted to pasture, where there might be danger of poisoning stock, to gardens, to orchards and to banks of irrigation ditches. The use of carbon-bisulphide should be restricted to periods when the ground is wet. Both traps and carbon-bisulphide are good "follow-up" methods in getting the gophers which refuse to take poisoned bait. Land that can be successfully flooded, so as to drown out the gophers, has usually been graded for irrigated crops such as alfalfa. Flooding (irrigation) is therefore automatic, and I have yet to see anyone who was so stupid that he would not hunt and kill gophers which were being drowned out. A man that kills all the gopher snakes and barn owls on his place will have to fight gophers, and deservedly so.

## 1. POISONING

The four things necessary to poison gophers successfully are: (*a*) an effective poison such as strychnine; (*b*) a succulent bait that will be relished by the gopher; (*c*) bait large enough so that the gopher must eat it at once and not put it in his pocket and carry it away to his storehouse; and (*d*) placing of the bait *in the main run* where the gopher can readily find it and not cast it out with the dirt, as would often be the case were it placed in an open hole or in a lateral.

In poisoning ground squirrels it has been found that strychnine is more readily absorbed through the membranous cheek pouches, which open inside the mouth, than through the stomach. However, the fur-lined pockets of the gopher which open outside the mouth do not readily absorb the strychnine. Hence poisoned bait, such as strychnine-coated barley, which is effective on the ground squirrel, is not effective on the gopher. The gopher often puts the poisoned grain in its pockets and carries it away to the storehouse, where the poison soon loses strength.

There are two methods of using strychnine. The first method, which is adapted to treating a large acreage, is given by Mr. de Ong in the second part of this bulletin. This method of placing the bait in the run through a hole made by a probe works well when the soil is damp. However, in cultivated fields when the ground is dry, a second method becomes necessary, as the dry surface soil will run in and promptly fill up the hole made by the probe. In this case it is best to dig down and place the poisoned bait well back in the main run of the gopher. Many times only a few poisoned baits are required. These may be prepared quickly and used as follows:

Carrots, parsnips, sugar beets or sweet potatoes, cut into one-inch cubes and poisoned by inserting a few sulphate of strychnine crystals into a slit made by the point of a knife, are good, especially in the dry season when green food is scarce. Carry the poisoned cubes in an old covered pail marked *Poison*. Find the main run in the same manner as when setting a trap, and with a slender pointed stick, so that you will not have to touch the bait, place one of the poisoned cubes a foot back in each hole, which should then be tightly closed. The hole may be opened forty-eight hours later and if it remains open the gopher may be considered dead.

Poisoned alfalfa has been found effective in orange groves in southern California. The heads of a few tender stalks are bent back and tied with a string so that the tuft is formed at the end. A little strychnine mixed with orange juice is concealed inside the tuft.

which is then pushed well back in the run, and the hole then tightly covered.

## 2. TRAPPING

Almost any kind of trap will catch gophers sometimes, a few will catch gophers most of the time, but we have yet to see the trap that will catch every gopher every time. There seems to be among experienced farmers throughout the state a decided preference for a gopher trap of the Macabee type (fig. 2*a*). After a practical test in the field, extending over several years, the "catching average" of this style of trap has been found to equal or surpass that of any other trap that the writer has been able to secure. Its cheapness, compactness, and reliability place it at the head of the list.

Any form of explosive trap, or "gopher-gun," is not recommended because of the degree of danger which attends its use.

### Where to Set the Traps

The most effective "set" for the Macabee trap is in the *main* runway (fig. 1*a*), and not in the lateral run (fig. 1*b*) that leads to the surface mound. This necessitates the use of two traps per setting, one in each direction; but the results are so much more certain and quicker that the *catch per trap per day* is greater than where but one trap is set in a lateral run, where it is often filled full of dirt by the gopher. A common stiff-handled twelve-inch iron spoon is of great assistance in finding the main run and in properly placing the trap. This spoon had better be supplemented by a light short-handled shovel, for the man that is afraid to dig will never get rid of his gophers. The freshest mound should be selected and the probable direction of the main run determined by noting the angle of the dirt-plugged hole. The mounds are usually situated one or two feet distant from, and nearly at right angles to, the main run.

Now to business: Take the bowl of the iron spoon in your hand and push the other (handle) end of the spoon into the ground where you think the lateral, which leads from the mound to the main run, is. If the spoon strikes an open lateral you will feel the spoon handle drop through the opening. If the lateral is filled loosely with dirt the drop will be less noticeable but still plainly felt. If it is plugged tight you will have to use the shovel to dig down a little distance before probing again. If this fails, try a new mound. When the lateral is found, follow it down to the main run, which is always kept open by the gopher. Use the shovel until you have cleared a place where you can set a trap in each direction. Smooth out the hole with

the spoon but do not disturb more than is necessary. Set the treadle, or pan, so that a slight touch will spring the trap, and place the trap *well back* within the hole. A little loose dirt should be left in the bottom of the hole, as it will cover the prongs and front end of the trap when the trap is pushed into place. When in place, press the trap down firmly so that it will not slide back if the gopher pushes against it. Then plug the burrow with a clod or a handful of grass or alfalfa and cover completely so that no light can get to the trap. A gopher's instinct prompts him to tightly close all open burrows to keep out his natural enemy, the gopher snake (nature's own gopher

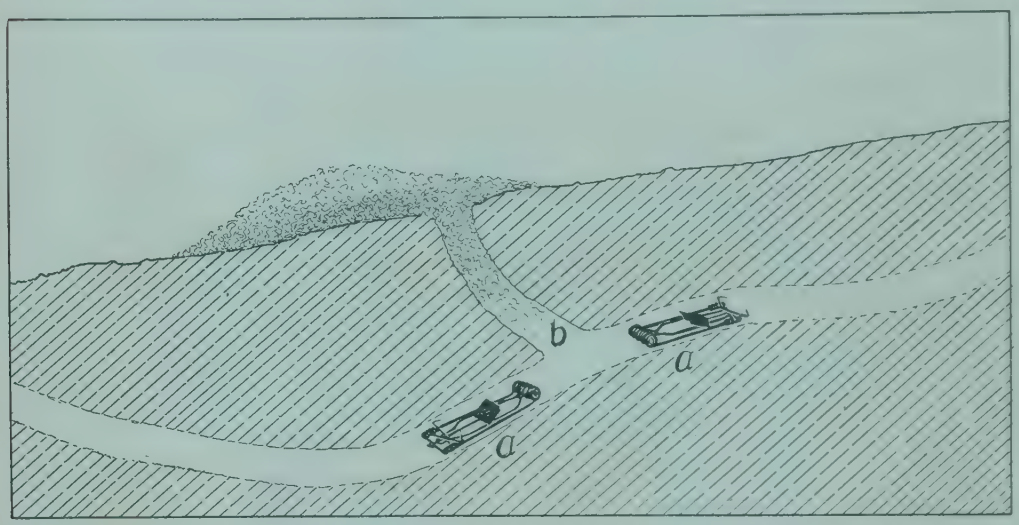


**Fig. 1.**—*a.* Best place to set traps or leave poisoned bait, in the main run which is always kept open by the gopher. *b.* Lateral run, usually partly plugged with dirt, leading to surface mound.

trap). Therefore, if poisoned bait or a trap be placed in an open hole, or the hole be left open, the poisoned bait will often be thrown out, to become a menace to stock, or the trap sprung by the dirt which the gopher pushes ahead of him in plugging the open hole. Set the traps and place the poisoned bait *well back in the main runs,* which should then be *tightly closed.*

The trap should have a wire or light chain attached to it and fastened to a chunk of stove-wood or, better still, an old worn-out stewpan which will rattle should you forget and run over the set trap with a harrow or cultivator. Coyotes and house-cats dislike the noise, also, and do not drag the trap so far when they rob it. In case only one trap is available when the main run is found, a careful watch will often, but not always, reveal one or more little flies emerging from the run where it is first opened. These flies seem to have a direct

relation to the gopher, as experiments have shown that the side that they come from is the one occupied at that time by the gopher and hence the place to set the trap. Traps should be visited morning and evening, or oftener.

### Special Sets

Individual gophers will frequently be found that refuse to enter any sort of trap. These gophers are generally old males and are likely to be the ones that do most of the gnawing on fruit trees. When one of these old-timers repeatedly fills the trap with dirt, then special

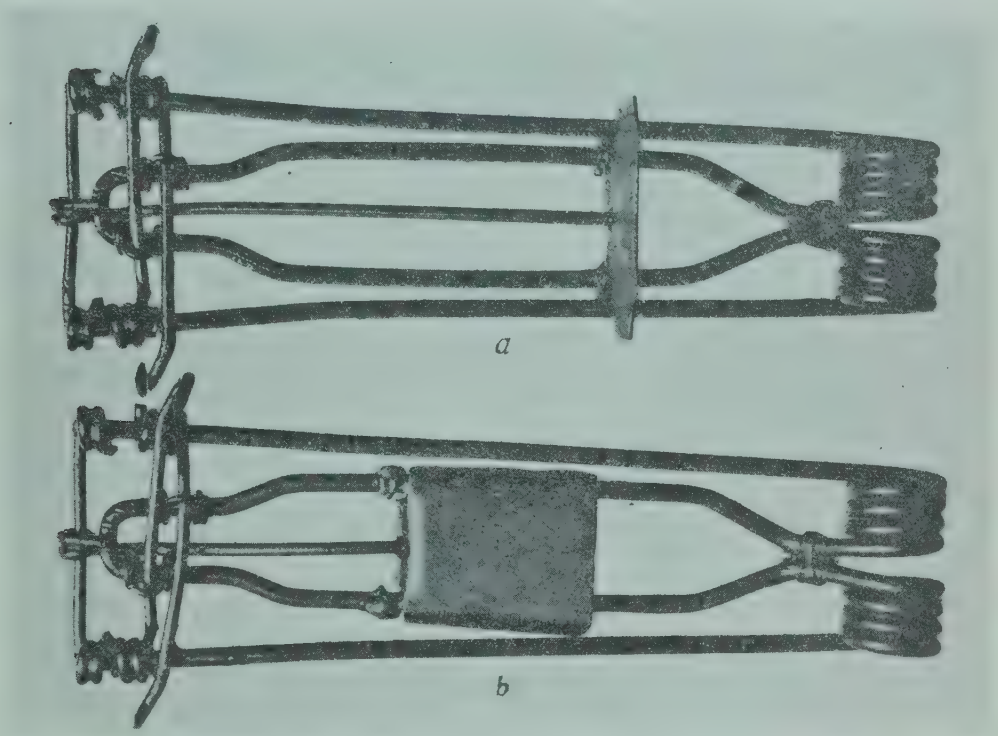


Fig. 2.—*a*. Regular Macabee gopher trap. *b*. Reconstructed Macabee trap used to catch "wise" gophers, and moles.

care becomes necessary to catch him. Moles may be captured in this way also. Take a Macabee trap (fig. 2*a*) and move the treadle forward about an inch and a half, placing the wire which carries the treadle below, instead of above the two longitudinal wires. Cut off the wire trigger to meet this change (fig. 2*b*). Then bend the treadle backwards at right angles to its former position (fig. 3*a*) so that it will lie parallel with the trap (fig. 3*c*), instead of sticking up at right angles and obstructing the runway (as in fig. 3*b*). Set the trap so it will spring easily. Put a pinch of loose cotton under the treadle to keep the dirt out, and when the trap has been placed in

the run take a stick and cover the whole trap with a thin layer of loose dirt. Another method is to take a recently caught female and rub the reproductive parts on the face of the treadle of the regular Macabee trap. A few drops of urine may be squeezed out during the process, but this only adds to the efficacy of the decoy. If all else fails catch a gopher snake and turn him loose in the run.

After you have put in poison or traps the tops of all the gopher mounds should be kicked off, so that when you make your next round the newly made mounds will tell you where gophers remain and where to put out more poison or traps.

The reconstructed form of the Macabee trap above described will be furnished by the manufacturer if the demand warrants.

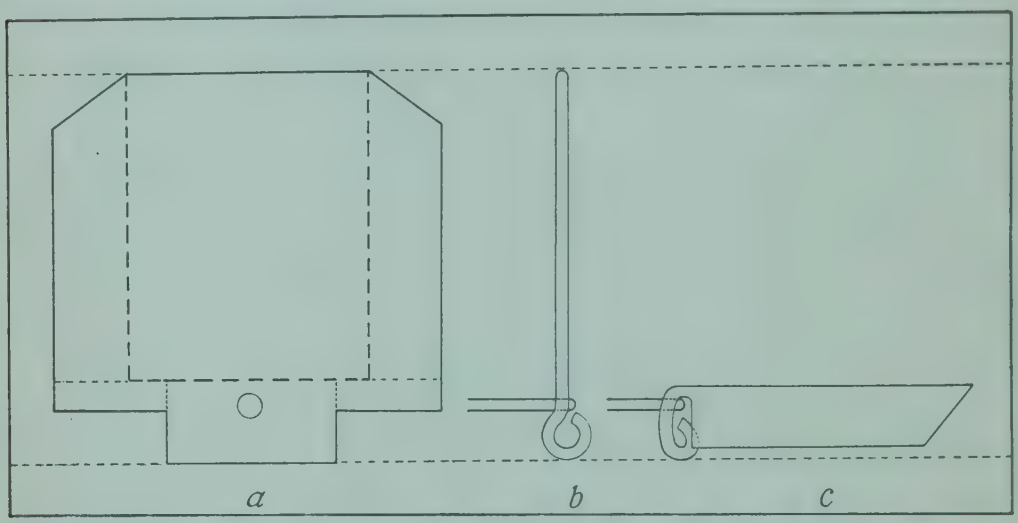


Fig. 3.—*a*, *b*. Vertical "treadle" or "pan" of regular trap; heavy dotted lines show places to bend vertical treadle to form horizontal treadle (*c*).

### 3. CARBON BISULPHIDE

Carbon bisulphide is volatile as well as inflammable and the gas from it is explosive, so that caution should attend its use. Its use is advisable only when the ground is damp or full of water, as the cracks in dry ground let the gas escape. It does not seem to be as effective on gophers as on ground squirrels, for the gopher burrows are much more extensive and the gopher is therefore harder to reach. It is more valuable as a "follow up" method than for general application.

There are two methods of applying carbon bisulphide. The first is to pour about a tablespoonful on cotton waste, corncobs or other absorbent material, which is then quickly pushed down the hole and the opening promptly and tightly closed. The better way is by the

use of a special apparatus which forces the gas down the hole. This is accomplished by a hand bellows attached to the top of a tank that contains the carbon bisulphide. The air is forced through a pipe from the bellows to the tank, where it passes over the bisulphide and is carried out through a rubber hose which is pushed down the open hole and then tightly surrounded by dirt. Contrivances of this sort, such as the Eureka Squirrel Exterminator, are on the market.

### 4. FLOODING

As has been pointed out above, flooding of fields often is an essential part of agriculture in irrigated sections. The main point, then, is to see to it that the gophers which are drowned out and seek the higher borders, are promptly dispatched. A good dog will do this effectively until he gets tired, and then the farmer must be ready to give the gophers proper attention with the back of a shovel.

### 5. ENCOURAGEMENT OF THE GOPHER'S NATURAL ENEMIES

Comparatively few ranchers realize the true value of barn owls and gopher snakes as allies in their war on gophers. A pair of nesting barn owls were found by the writer to catch from three to six gophers a day for their young. No one who has ever counted the number of rodents brought in by a pair of these owls during a single season would ever doubt their value as gopher destroyers.

On May 13, 1914, near Mendota, Fresno County, California, Mr. John G. Tyler[2] found two pairs of barn owls nesting in an old tank house. "One nest was placed in the tank on the bones, fur, pellets, and refuse that had accumulated to a depth of several inches. One bird was perched on a beam overhead asleep, while his mate occupied the nest, which contained four very small birds and six eggs. Scattered about on the floor were five pocket gophers (*Thomomys*), five kangaroo rats (*Perodipus*), one pocket mouse (*Perognathus*), and two white-footed mice (*Peromyscus*), all of which were in good condition and undoubtedly of the previous night's capture. Besides these, there were partly eaten remains and fresh skeletons of several more. . . . If the thoughtless persons who so relentlessly destroy this owl on account of its supposed fondness for chickens and pigeons would take the trouble to keep watch of a nest-site through one season, the most ignorant among them could hardly fail to realize that they are working against their own best interests whenever they kill a barn owl."

[2] *Condor*, XVII, January, 1915, p. 57.

The gopher or bull snake may steal eggs occasionally, but his main diet consists of small rodents, chiefly gophers. A wise man will therefore protect the gopher snakes on his premises. *Every gopher that the barn owl or gopher snake destroys means one less for you to catch.*

## OTHER METHODS OF CONTROL

Some other methods of controlling pocket gophers are: (1) protecting trees with wire netting; (2) planting gopher repellant plants; (3) using rodent virus; (4) surrounding small plot by a trench; (5) protecting of ditches by cement.

### 1. PROTECTING TREES WITH WIRE NETTING

One-inch mesh galvanized wire netting in the form of a cylinder one foot in diameter and eighteen inches high may be placed about young trees when they are planted, to protect them from the attacks of gophers. The top of the netting should be put just below the surface of the ground, and the trunk of the tree above ground protected in some other way so as not to interfere with cultivation, which the netting will certainly do if it sticks above ground.

### 2, 3. GOPHER REPELLANT PLANTS; RODENT VIRUS

Plants which will drive gophers away, and a virus of a "gopher infectious" disease, have both been much exploited, but neither remedy seems to have "made good," and cannot therefore be recommended.

### 4. SURROUNDING SMALL PLOT BY A TRENCH

Small plots of ground have been protected by being entirely surrounded by a trench eighteen inches wide and two feet deep, with open five-gallon cans buried flush with the bottom in the ditch at twenty-five foot intervals, to catch and hold the gophers which tumble into the ditch, and thence into the cans.

### 5. PROTECTION OF DITCHES BY CEMENT

A power company which had much trouble with gophers in a large ditch dug a four-inch trench six feet deep straight down through the middle of the lower bank of the ditch. The dirt was loosened with an iron bar and removed with a narrow shovel, of the type used in digging telephone-pole holes. The trench was then filled with a "lean" mixture of cement and sand, which was carried on a barge that floated on the water in the ditch. The cement was conveyed to the bottom

of the trench by a galvanized iron chute which was built in sections so as to be readily adapted to any depth. This method was said to have been expensive, but satisfactory in the long run.

A small irrigation ditch having a seven-foot "surface" has been protected from gophers, weeds and leakage by applying to the sides and bottom, first a ⅞-inch coat of 7 to 1 cement and then a surface layer ¼ inch thick of 3 to 1 cement. This proved satisfactory.

All of these preventatives are costly and are advisable only in those situations where protection against gophers cannot be obtained by their destruction.

# II. A METHOD OF POISONING POCKET GOPHERS

By E. RALPH DE ONG
Agricultural Experiment Station, University of California

One of the most satisfactory, and at the same time, one of the cheapest methods of controlling pocket gophers is through the use of poisoned baits, such as chopped vegetables, dried prunes, or raisins. The formula[3] which has proved very successful at the University Farm is as follows:

| | |
|---|---|
| Sweet potatoes, parsnips, or carrots | 8 quarts |
| Flour paste | ½ pint |
| Strychnine alkaloid, powdered | ¼ ounce |
| Saccharine | 1/16 ounce |

Chop the vegetables, or cut them with a knife, into one-half inch cubes. Make a thin paste of flour and water and boil for a few min-

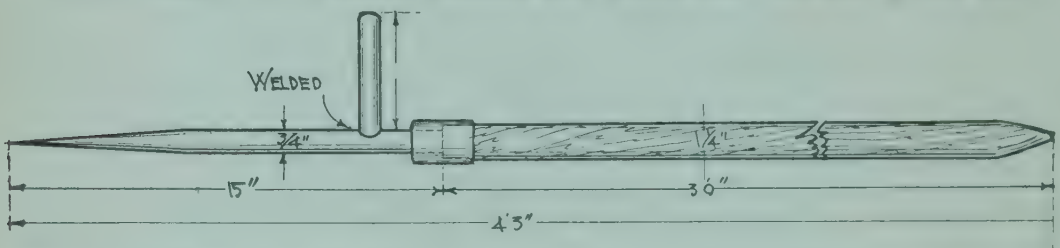


Fig. 4.—Tool for probing ground so as to locate underground burrows of pocket gophers.

utes. Stir the strychnine and saccharine into one-half pint of the cooked paste and pour it over the chopped vegetables, stirring until each piece is coated. Two or three or these cubes are to be dropped in each runway. The alkaloid form of strychnine should be used in preference to the sulphate, as the former is but slightly soluble in water and remains largely on the outside of the bait, leaving the center sweet. The saccharine is used to disguise partially the bitterness of the strychnine.

To locate the underground burrows, the method previously recommended will prove satisfactory, or a simple tool may be used, which can be made at any blacksmith shop. This is a shank of steel, three-quarters of an inch in diameter and about fifteen inches long, pointed

[3] U. S. Dept. Agric., Farmers Bulletin No. 484, p. 39.

at the lower end. This is fitted into a wooden or iron handle, three feet long, one end tapered slightly, to be used in enlarging the openings made into the runway. To aid in sinking the probe into the ground, a foot-piece should be welded on to one side of the steel rod (fig. 4). To use this tool it is necessary for the ground to be wet down to the ordinary depth at which the gophers are working, usually from three to eight inches below the surface. Sink the probe into the ground, ten or fifteen inches from the gopher hill, continuing the work until the burrow is located, which will be recognized by a sudden dropping of the probe. If necessary, enlarge the opening into the runway with the blunt end of the handle, then drop in the bait, and close the hole with the foot. The operator will soon become expert in locating the runways so that, where gophers are abundant, one man may bait hundreds of runs in a single day. One piece, of seven acres of heavily infested alfalfa land, has been covered by one man in a day and a half.

Poisoning is more successful from late summer, after green food has become scarce, until grass starts in the fall or winter, depending on rainfall and temperature. It should be delayed until the top layer of ground is thoroughly wet, not only to facilitate operations, but because, after the heavy rains begin, gophers have a tendency to migrate into fence rows or the uncultivated strip along driveways, which greatly reduces the amount of ground necessary to cover. One thorough application in such places should kill 90 per cent or more of the gophers. After another rain the ground can be gone over again and any fresh hills poisoned. Alfalfa is not as successfully treated as orchard or bare land, on account of the abundance of succulent food.

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# THE OLIVE INSECTS OF CALIFORNIA

BY
E. O. ESSIG

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# THE OLIVE INSECTS OF CALIFORNIA

By E. O. ESSIG

## INTRODUCTION

As compared with other trees in California, the olive is attacked by comparatively few insects and in many localities is almost entirely exempt from regularly destructive pests. The industry, however, is so large and conditions of insect work so varied that it seems advisable to collect all of the available information regarding the insects which infest this crop in one paper. The subject matter is discussed under the two general heads: I, the more important olive insects in California, and II, insects of minor importance to olive trees in California. There is also included at the end a brief discussion of some of the most important olive insects of other states and foreign countries which have not gained access to this state or, as in a few cases, do not attack the olive here.

The writer is specially indebted to Prof. C. W. Woodworth of the Division of Entomology and to Prof. Frederic T. Bioletti of the Division of Viticulture and Enology for many helpful suggestions and corrections.

## I. THE MORE IMPORTANT OLIVE INSECTS IN CALIFORNIA

### THE BLACK SCALE

*Saissetia oleae* (Bernard)

Figures 1 and 2

The black scale is the commonest and most troublesome insect pest of the olive in California, but there are many districts which have always been practically free from serious attacks. The young are liable to be killed by hot, dry weather and therefore the insect does not find the climatic conditions of the warmer valleys so favorable to its growth as those along the coast. However, it is gradually encroaching upon territory claimed a few years ago to be absolutely immune because of the hot, dry summers.

In most other states and especially in Europe, this insect is commonly known as the olive scale or olive cochineal and has received the specific name *oleae* from the olive which it commonly attacks. In California, it has always been called the black scale, either because of the dull black color of most of the females or because this insect is the one chiefly responsible for the growth of the black smut fungus over the leaves, stems and fruit of the infested plants. It has one

of the most characteristic markings to be found among the scale insects, consisting of a very plain elevated letter "H" upon the backs of both the young and old females. The male scales, which are much smaller than the females, are usually entirely wanting and when present appears as very thin, transparently white exuviae, from which the males, after undergoing transformation, emerge as tiny two-winged insects. This occurs when the females are about one-third or half

Fig. 1

Fig. 2

Fig. 1.—The black scale, *Saissetia oleae* (Bern.). The young females as they appear on the olive leaves and twigs during the winter months. (Original).

Fig. 2.—Adult females of the black scale, *Saissetia oleae* (Bern.), on an olive twig. (Original.)

(Photos by Div. Sci. Illust., Univ. Calif.)

grown. After mating, the males die, and so it is that even when present, because of their small size, entirely different form, and short life, they are not generally known to the orchardists. The females, however, are always in evidence, and do the damage to the trees. They reach maturity in most localities during the months of June, July and August and lay from 100 to 3000 small oblong or oval whitish or amble-colored eggs which remain beneath the large, nearly hemispherical hollow body, the underside of which shrivels as the

eggs are laid till scarcely more than a thin shell remains. Upon hatching, the young, which have much endurance for such small creatures, crawl from beneath the bodies of the parents and seek suitable feeding places. The majority first settle on the undersides of the leaves along the midribs while the remainder seek the smaller twigs. Many, of course, perish during the winter, but by spring there are still great numbers remaining, and chiefly those which settled on the twigs. Those on the leaves also move to the twigs and remain there during the rest of their existence or until the old dead bodies fall off. The cold winter months are not conducive to growth, but with the coming of the warm spring days, development is rapid and the excrement, known as honeydew, begins to appear in quantities over the trees. This sweet excrement is the food of a black smut fungus, which, though an after-effect, is the most serious feature about this and many other scale insects. It is the prevention of the smut fungus that most often prompts the control of the black scale. The fungus serves as a good index to the time for spraying.

The black scale is a general feeder and attacks a large and ever-increasing number of plants, the known list for all countries including: almond, *Antidesma,* apple, apricot, mountain ash, aster, beech, buckthorn, camellia, California nutmeg, deodar cedar, *Cestrum,* chrysanthemum, citron, *Duranta,* eucalyptus, fig, fuchsia, geranium, grape, grapefruit, *Grevillea, Grewia,* groundsel tree, guava, English holly, mountain holly or Christmas berry, St. John's wort, jasmine, Irish juniper, laurel, lemon, black locust, honey locust, magnolia, mahogany, maple, *Maytenus, Melaleuca, Myoporum,* nightshade, oleander, olive, orange, trifoliate orange, orchids, palms, periwinkle, pigeon pea, pear, pepper tree, phlox, plum, pomegranate, poplar, privet, prune, rose rubber, sage, sumach, sycamore, tangerine, sago palm, strawberry tree, Thespesia, *Veronica,* and watermelon.

Considering the whole state, very little has been done towards the control of the black scale on olive trees. In a few of the large commercial plantings, particularly along the coast regions, some attention is given to the insect and control measures are employed whenever necessary. These control measures have been well worked out and have given very satisfactory results. In a few instances fumigation has been used in the citrus districts with marked success, but the cost as compared with spraying is so much greater that the latter practice is now almost universally followed where treatments are advantageous. The hardiness and resistance of the olive trees are remarkably great, making it possible to apply very strong sprays without injury to the fruit or foliage. Normally, the dormant sprays for deciduous

fruit trees are used, but it is advisable in most cases to reduce their strength about one-fourth to one-third, especially if the fruit is well matured on the trees. The materials used are chiefly oil emulsions, miscible oils and soap powders, although the rosin wash and the distillate-caustic soda-water mixture have also been used with success. The oil emulsions may be prepared at home or purchased from reliable manufacturers. Many growers, realizing the difficulty of securing proper materials for home preparations and the variability of the homemade mixtures, even under the best conditions, prefer to buy manufactured products, especially when only small quantities are needed. For those who desire a homemade product the following formula may be followed for a *crude oil* emulsion:[1]

| | |
|---|---|
| Crude oil (21° to 24° Baumé) | 15 gallons |
| Liquid soap (or 20 lbs. hard fish oil soap) | 3 |
| Water | 175 |

Place the required amount of water in the spray tank and add the liquid soap; agitate thoroughly and pour in the crude oil, continuing the agitation until the mixing is complete and no free oil remains on the surface and also during the application to the trees.

The *distillate-caustic soda-water mixture* is easily prepared as follows:

| | |
|---|---|
| Distillate (28° Baumé) | 7 gallons |
| Caustic soda (95%) | 5 to 7 pounds |
| Water | to make 200 gallons |

First dissolve the caustic soda in a small amount of water and add to the water in the spray tank; begin the agitation and slowly add the distillate, continuing the agitation during the application. This spray will also remove the lichens or moss from the trees.

The *rosin wash* is chiefly used for young and tender nursery stock, because it does not cause the injury often following the application of the previously named materials in such cases. The preparation is:

| | |
|---|---|
| Rosin | 10 pounds |
| Caustic soda (76% to 95%) | 3 to 2½ |
| Fish oil | 1½ |
| Water | to make 50 gallons |

To a gallon of hot water in an iron kettle add the fish oil and the rosin and heat until the latter is softened; after first dissolving the caustic soda in a small quantity of water add it and stir the mixture thoroughly, after which pour in enough water to make fifty gallons of spray material.

[1] All of the spray formulae are reduced to meet the average needs for olive trees. They may be strengthened by one-fourth to meet extraordinary conditions.

The *miscible oils* cannot be satisfactorily prepared at home and should be purchased from a reliable manufacturer or dealer and used according to the directions that accompany them.

The oil emulsions, distillate-caustic soda-water mixture and the miscible oils often separate in the spray tank if the water contains much mineral matter and should be applied only with a good power

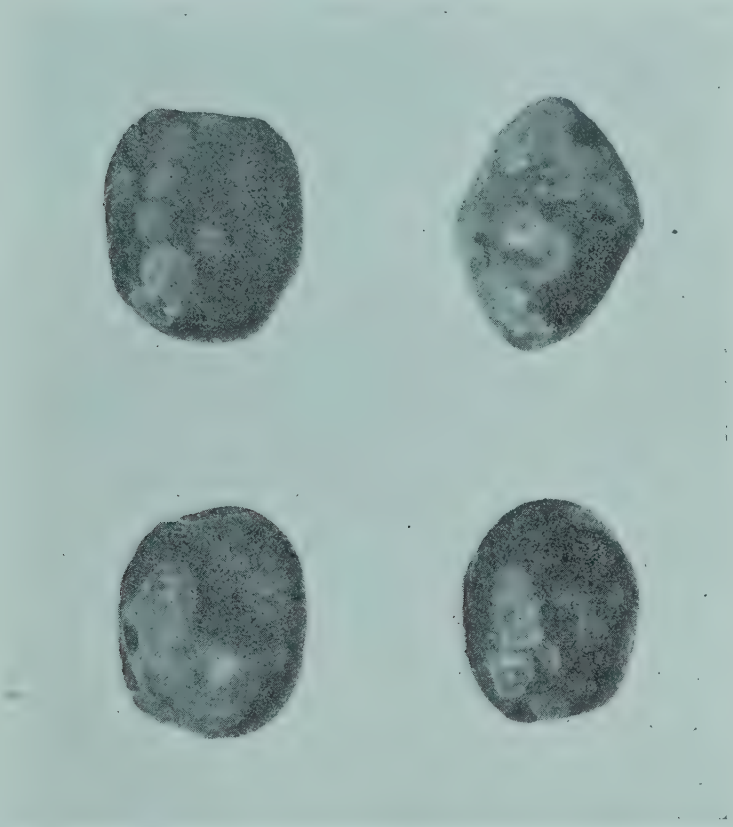

Fig. 3.—The ivy or oleander scale, *Aspidiotus hederae* (Vall.), and its work on the fruit of the olive. (Original.)

(Photo by Div. Sci. Illust., Univ. Calif.)

machine with a forceful agitator, which must be kept going during the entire process of application to avoid oil injury to the trees.

The *soap powders* are a revival in a somewhat different form of an old spraying material (soap) and in the present form are comparatively new in spraying work and are meeting with much favor because of their comparatively cheapness, ease of handling and efficiency. They are put up in barrels, and are ready to add directly to the water in the spray tank, dissolving readily in cold water with a small amount of stirring or agitation. The average dose is about one pound to every five gallons of water.

The best time to kill the scale is during the period just following hatching, usually in August and September, but fair results may be expected at any time from the middle of August to the first of January.

The proper quantity of material should be applied in the form of a rather coarse driving spray under a pressure of from 100 to 200 pounds. For the average-sized tree from five to seven gallons should be sufficient to thoroughly cover every portion adequately.

A sufficient number of scales to produce any noticeable amount of honeydew and cause a corresponding degree of smutting should be sufficient evidence to warrant spraying.

In spraying an orchard, it is important to keep the following in mind:

1. In case of doubt as to the strength of materials to use, spray a few trees to ascertain results before treating the entire orchard. Allow about two weeks to get the full results of the chemicals.

2. Never spray when the orchard is in need of water, as severe burning of fruit and foliage may result. Irrigate first or wait until after the first rain.

3. Do not spray during excessively hot weather or when hot winds are blowing.

4. Do not spray within several weeks before picking, if possible, as spotting of the fruit may result.

The control of the black scale by natural enemies has long been the subject of much experimental work without any very definite results. True, a number of predaceous and parasitic insects have been introduced to combat it, but their combined efforts are not sufficient to be a reliable factor in the control of the pest in the orchards.

The predaceous insects include the following:[2] the black ladybird beetle, *Rhizobius ventralis* Er., the ashy-gray ladybird beetle, *Olla abdominalis* (Say), *Lindorus lopanthae* (Blaisd.), the steel-blue ladybird beetle, *Orcus chalybeus* (Boisd.) and *Axion plagiatus* Oliv. Of these, the first is the only one of importance. It was first introduced into the olive orchards of Santa Barbara County and has since been distributed generally throughout the state. The larvae and adults feed upon the black scale and in some districts become quite abundant. *Lindorus lopanthae* (Blaisd.) is also quite widely distributed and preys partially upon the black scale. The others seem never to become very numerous or important.

[2] For a complete list, discussion and illustrations of predaceous and parasitic insects of the black scale, see Bul. 223, Calif. Agr. Exp. Station, July, 1911, by Prof. H. J. Quayle.

Among the parasitic insects, are the scutellista, *Scutellista cyanea* Mots., also known as the African fly, *Dilophogaster californicus* (How.), *Aphycus* sp. and the lecanium parasite, *Coccophagus lecanii* (Fitch). Of these the scutellista is by far the most important and at times becomes remarkably numerous, infesting nearly every egg-laying female of the scale. The larvae feed upon the eggs, but usually

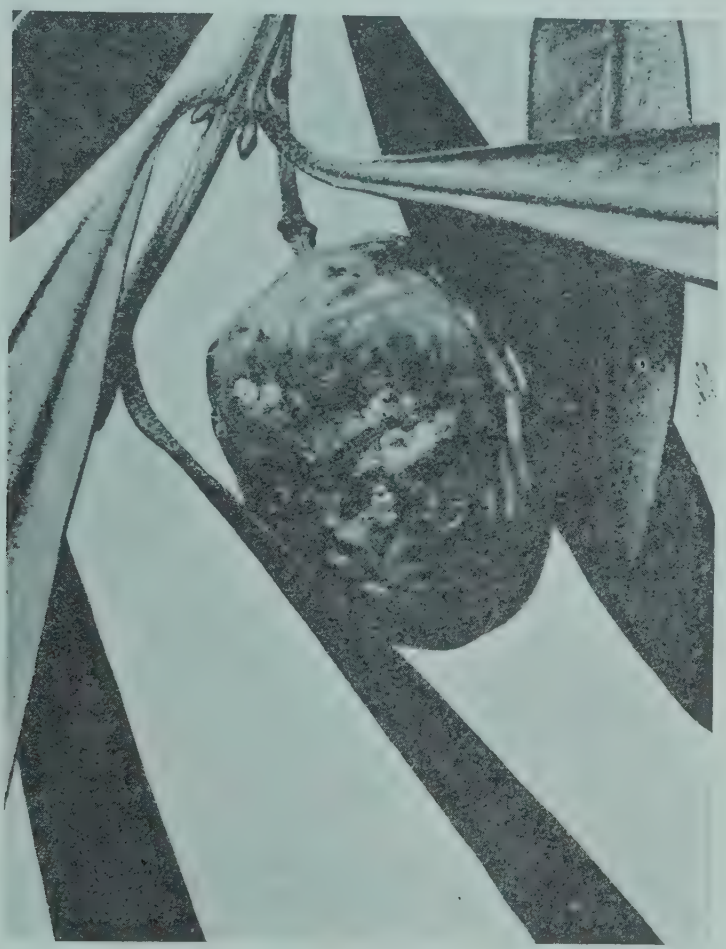

Fig. 4.—The ivy or oleander scale, *Aspidiotus hederae* (Vall.). Adult females and young on an olive. (Original.)

leave enough to insure little or no diminution in the number of scales for the next year. Though not at all dependable, it is often relied upon by growers to do what can be accomplished with certainty with sprays, with the result that considerable loss is caused by the omission of control measures every year. The other parasites listed work much more spasmodically and little real investigation has ever been done to ascertain whether they do any good or not.

The state insectary is still continuing its endeavors to introduce parasites which will prey more effectively upon the immature stages of the black scale and it is hoped that every success will attend their efforts so as to reduce the expensive operation of spraying.

## THE IVY OR OLEANDER SCALE

*Aspidiotus hederae* (Vallot)

Figures 3–6

In some parts of the San Joaquin and Sacramento valleys, this insect often becomes quite abundant on the leaves, and, in a few instances, on the fruit of the olive trees. In the latter case, it is

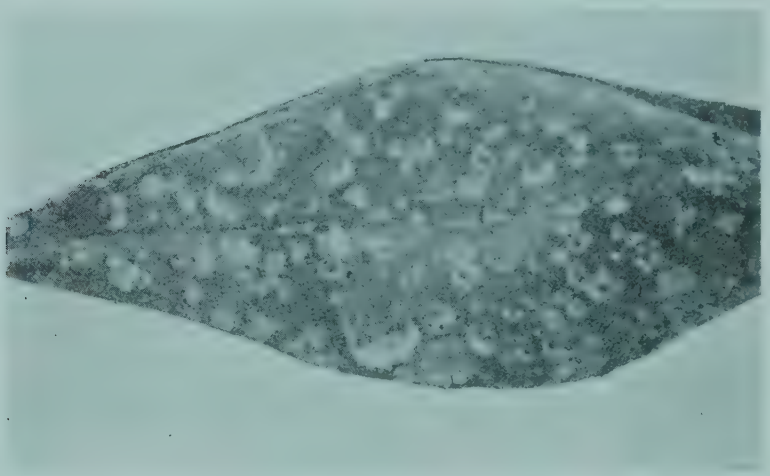

Fig. 5.—The ivy or oleander scale, *Aspidiotus hederae* (Vall.), on an olive leaf. (Original.)

(Photo by Div. Sci. Illust., Univ. Calif.)

specially annoying to the growers of ripe pickling olives. The infested fruits become spotted because the retarded development of the tissues around the scales leaves pits or depressions and the checking of the coloring in these places causes them to remain green while the rest of the fruit assumes the natural dark color (fig. 3). The insect gets its common names from the two plants most universally attacked, although in this state others are as commonly infested. It is what is called a true armored scale; that is, the female has over its small, nearly circular, yellow body a protection in the form of a thin gray or whitish circular scale about one-twelfth of an inch in diameter. The scale of the male is more elongated and somewhat smaller, the mature insect being small and winged as in the case of the black scale. In most cases, the scales are scattered over the surface of

the foliage in a very irregular way, while in others they are so thick as to overlap. On the fruit of the olive they occur in small colonies, each group often being composed of a single female and her progeny. The young are born alive and move freely until the first molt, when they lose their legs and must remain throughout the rest of their existence in one spot. Breeding continues almost throughout the entire year in many parts of the state, but it is much more rapid throughout the summer months.

As in the case of the black scale, the list of known food plants is very large and ever increasing, including, in all countries, the follow-

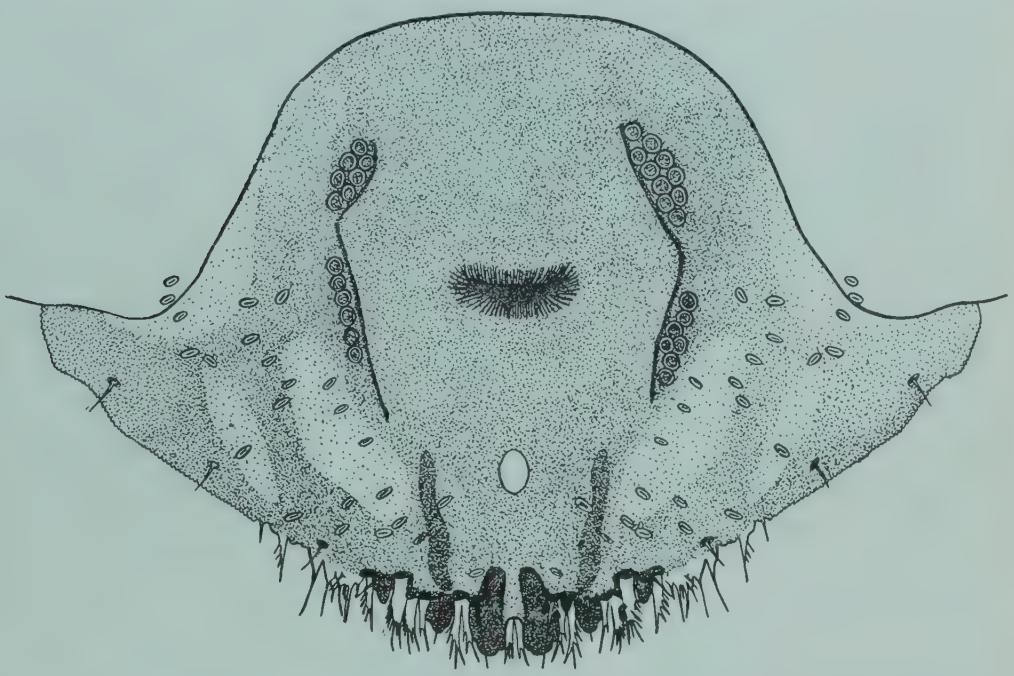

Fig. 6.—The ivy or oleander scale, *Aspidiotus hederae* (Vall.). Drawing of the pygidium of a female. Greatly enlarged. (Original.)

ing: Acacia, aloe or century plants, asparagus ferns, betel nut, boxwood, buckthorn, butcher's broom, California laurel or pepperwood, cactus, camellia, carob, *Carpodetus serratus,* cherry, citron, clover, currant, daphne, date palms, eucalyptus, fan palms, genista, grapefruit, grasses, *Hakea alliptica,* holly, English ivy, kentia palms, lemon, *Macrozamia,* madder, magnolia, manzanita, maple, mistletoe, Monterey pine, mulberry, *Myrsine retusa,* nightshade, oleander, olive, orange, orchids, oxalis, pepper tree, periwinkle, plum, pomegranate, *Prunus boldus,* holly oak, red-bud, redwood, rubber, sago palm, sumach, umbrella plant, umbrella tree, *Vitex littoralis, Vriesia splendens,* yew and yucca. From this list it will be seen that in-

festation may occur from a large number of sources outside the orchards.

The control of this insect is seldom attempted, for the actual loss does not, in most cases, justify the cost of treatment. Where control is desirable the oil emulsion and miscible oil sprays as recommended for the black scale should be used.

Natural enemies have never been considered of any consequence in the control of this scale, although there are both ladybird beetles and hymenopterous parasites that prey upon it in California as elsewhere.

## THE BRANCH AND TWIG BORER

*Polycaon confertus* Leconte

Figure 7

The work of this beetle, which consists of small, round holes from one-eighth to one-fourth of an inch in diameter and usually less than an inch in length at the base of a bud or in the fork of a small branch, is familiar to many orchardists. Occasionally one also finds the beetle itself at work in the holes. It is small, brown and black and about half an inch long. The object of its work is probably to secure food, as no eggs are deposited or young reared in anything but dead wood, while the burrows in orchard trees are always made in perfectly healthy and living tissue. The injury is due to the breaking of the twigs at the holes, and the improper pruning of the trees which results. The young trees suffer most, though old trees are quite as commonly attacked. Plants known to be thus injured are: almond, apple, apricot, cherry, currant, fig, grape, lemon, olive, orange, peach, pear, plum and prune. As previously stated the insect normally breeds in dead wood, chiefly of the madrone, oak, and old grape canes where the larvae may often be found in great numbers.

The beetle occurs generally throughou the state, but has been most annoying in the Sacramento, San Joaquin, and Santa Clara Valleys and the central coast region. The attacks are spasmodic and of short duration and the damage done through a succession of years is really slight. Regular control measures have never been tested out because they are generally unnecessary. The elimination of the dead wood in which the insect breeds might be suggested as a preventive measure and in young orchards, where the attacks are severe, it might be advisable to go over the trees about once a week and kill the beetles in the burrows with a wire or knife blade.

## THE OLIVE BARK-BEETLE

*Luperisinus californicus* Swaine

Figures 8 and 9

Though at present a comparatively unknown insect, this beetle may possibly become one that must be reckoned with in the future, if we are to judge by what little is now known regarding its work. A few adults were first taken by H. A. Weinland, then Horticultural Commissioner of San Diego County, in the Mission Valley near the

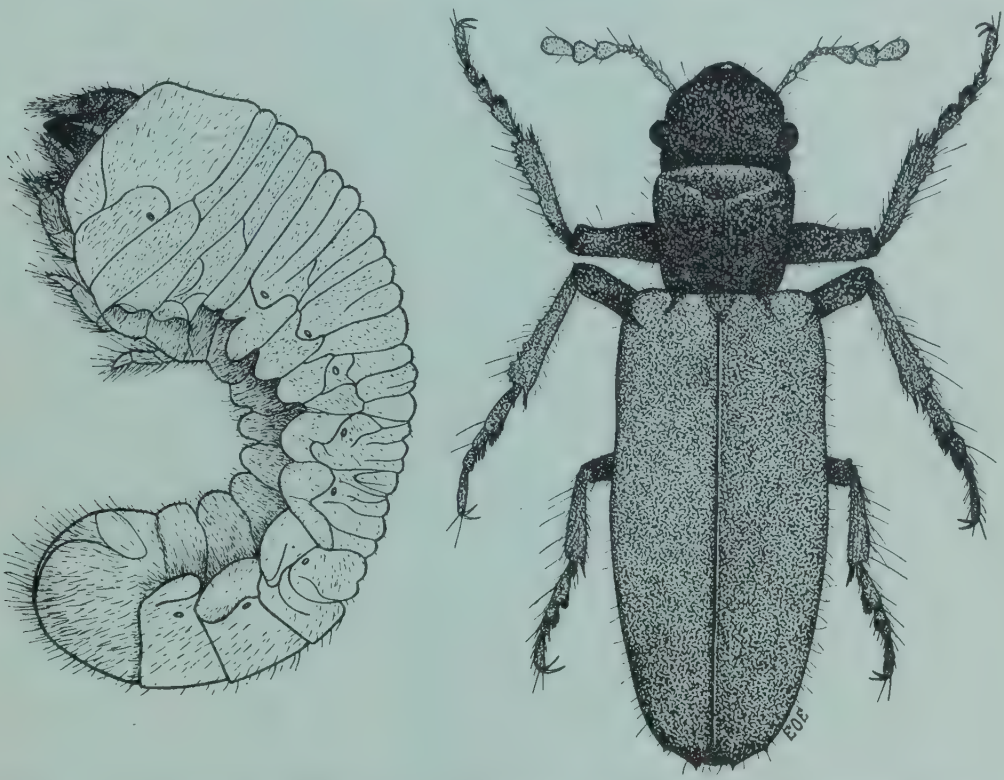

Fig. 7.—The branch and twig borer, *Polycaon confertus* Lec. Larva and adult. Enlarged. (Original.)

city of San Diego on May 17, 1915, and forwarded to the writer with the information that they were found injuring a living olive tree and might prove to be a serious pest. Other specimens followed from the same source on May 27 along with a piece of limb showing the work of the beetle and containing, within the burrows, a few cocoons of a hymenopterous parasite. On January 27, 1916, the present Horticultural Commissioner, Mr. H. M. Armitage, sent in a large number of the beetles as well as specimens of their work and a number of the parasites mounted on slides. The insect proved to be new to the university staff and they were forwarded to Mr. J. M. Swaine, Department of Agriculture, Dominion of Canada, a specialist in this

family of beetles, who pronounced it a new species and gave it the scientific name, *Luperisinus californicus*.[3] For a common name the writer has proposed the olive bark-beetle, which seems to be sufficiently descriptive.

Fig. 8.—The olive bark-beetle, *Luperisinus californicus* Swaine. Work and exit holes made by the larvae and adults on an olive limb. (Original.)
(Photo by Div. Sci. Illust., Univ. Calif.)

The insect is a small, robust beetle about one-eighth of an inch long, black with whitish scales forming a more or less definite pattern on the back, as shown in the drawing (fig. 9). The legs and most of the antennae are reddish and the entire body is covered with small simple and plumose hairs of various sizes. In general shape and size,

[3] *Canadian Entomologist*, vol. XLVIII, no. 6, pp. 190–192, June, 1916.

the adults resemble very closely the fruit-tree bark-beetle, *Eccoptogaster rugulosus* (Ratz.), a common pest to deciduous fruit trees in various parts of the state. The work also resembles that of this beetle and consists in the destruction of the cambium layer by numerous small burrows (fig. 8) which may entirely girdle the infested portions of the trees. The perfectly round entrance and exit

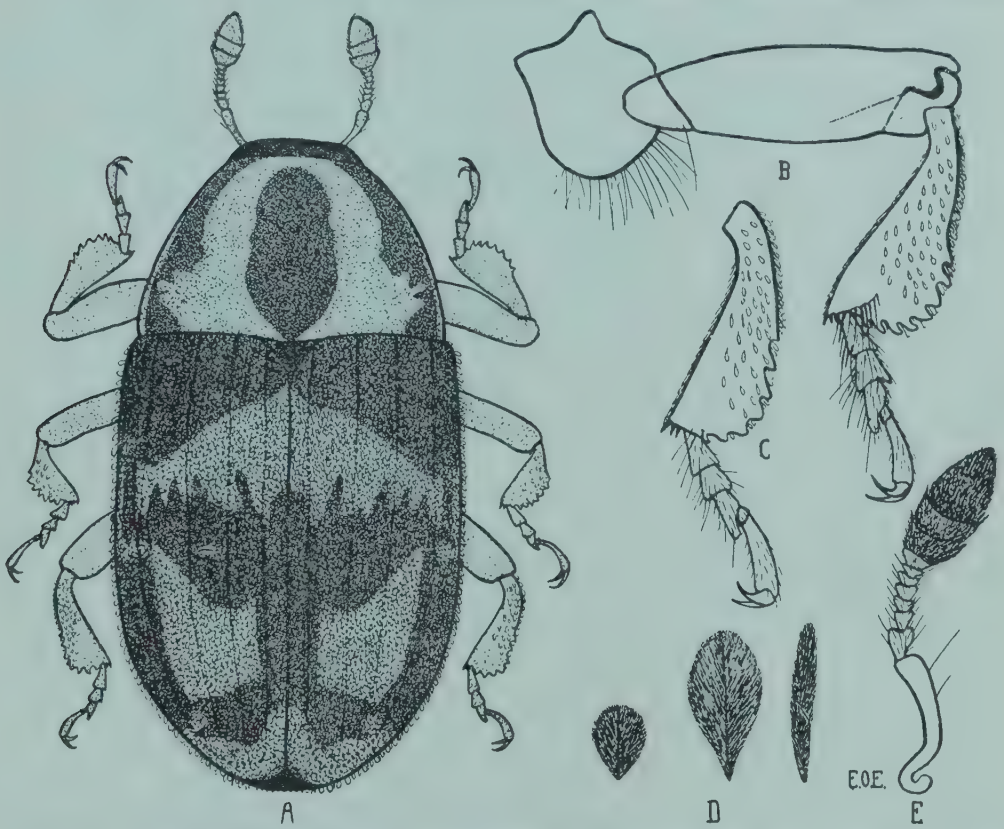


Fig. 9.—The olive bark-beetle, *Luperisinus californicus* Swaine. *A*, adult; *B* and *C*, leg and tarsi; *D*, plumose hairs from body; *E*, antenna. Enlarged. (Original.)

holes of the adults through the bark are the only distinct external evidences of the work, excepting the general unhealthy appearance of the infested trees. The insects apparently prefer sickly or dying trees and breed abundantly in them as well as in the dead prunings. However, like many of the orchard bark-beetles, they will not hesitate to attack perfectly vigorous and sound trees in close proximity to their breeding places, especially if an entrance may be gained through a sunburned or wounded spot.

The distribution of the species is not well known. Besides the infestation in San Diego County, already referred to, adults were taken at Camp Greely, Fresno County, as early as 1909 by Mr. Ralph Hopping,[4] but no host plants were recorded, the specimens having

[4] *Canadian Entomologist*, vol. XLVIII, no. 6, p. 192, June, 1916.

been collected in sweepings in the chaparral belt at an elevation of 3000 feet. So far there have been no reports of its attacking olive trees in Fresno County. On July 9, 1916, the writer received a small piece of olive bark from a grower at Bakersfield, Kern County, showing small exit holes exactly like those made by the insect in question, with the statement that the insect causing the injury had badly attacked the young olive trees with the result that one was already dying. The possibilities of its being the same thing are very strong, though no opportunity has been afforded to make a personal investigation.

As in the case of other orchard bark-beetles, the first essential in avoiding attacks is to maintain a healthy condition of all the trees and to prevent sunburn and injuries which lessen their vitality and furnish the proper conditions for the entrance of the beetles. The immediate burning of all prunings is also important, to eliminate possible breeding places around the orchards. After an orchard has become infested, the only effective step is to cut out and burn all infested limbs or trees as soon as discovered, to avoid spreading and continued attacks.

The small hymenopterous parasite[5] which attacks the immature stages within the burrows is not likely to be of much consequence in controlling the beetle.

## II. INSECTS OF MINOR IMPORTANCE TO OLIVE TREES IN CALIFORNIA

Of the following insects, it is not likely that any will prove of real economic importance, but they are included because they are sometimes found infesting the olive trees and excite the suspicion of the orchardists.

1. The citrus thrips, *Scirtothrips citri* (Moulton). Taken in the flowers of olive trees in the San Joaquin Valley.[6]

2. The bean thrips, *Heliothrips fasciatus* Pergande. Reported as seriously infesting the fruit of olives in San Joaquin County in 1915.[7]

3. The net-winged cicada, *Platypedia areolata* Uhler. Sometimes punctures the small limbs of the olive to insert its eggs. The punctures cause the twigs to become distorted or to break. The distribution is general throughout the state.

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[5] The parasite has been determined by Mr. Rohwer as *Ecphylus*, probably *schwarzi* Rohwer, through the kindness of Mr. Harry S. Smith, superintendent of the State Insectary.

[6] Jones, P. R. & Horton, J. R., Bull. no. 99, pt. 1, p. 3, Bur. Ent., U. S. Dept. Agr., 1911.

[7] Smith, H. S., Mthly. Bull. Cal. Hort. Com., vol. IV, p. 574, 1915.

4. The mountain-ash louse, *Prociphilus fraxini-dipetalae* (Essig) (fig. 10). This species rarely attacks the olive, having been taken by the writer on the tender sprouts at Berkeley, 1914, and on the leaves at Corning, the same year, by Chas. B. Weeks, Horticultural Commissioner.

5. The red scale, *Chrysomphalus aurantii* (Mask.). A citrus pest reported on olive in the southern part of the state by Prof. H. J. Quayle.[8] It was recently received from Roy K. Bishop, Horticultural Commissioner, who took it on olives in Orange County. The leaves were thickly covered.

6. The purple scale, *Lepidosaphes beckii* (Newm.). Also a citrus pest reported on olives in southern California by Prof. H. J. Quayle.[9]

7. The greedy scale, *Aspidiotus camelliae* Sign. (figs. 11 and 12). Very common on the bark of the branches, especially of old suckers. It may be easily mistaken for the ivy or oleander scale, the color being much the same, but the outside shell is more robust, nearly conical in shape and with the small exuvia or nipple at one side rather than at the middle. The characters of the anal plate, as shown under the microscope (fig. 12) at once separate it from the ivy or oleander scale (fig. 6). Though often abundant, it does not seem to hurt the infested portions in any noticeable way.

Fig. 10.—Apterous females and young of the mountain ash louse, *Prociphilus fraxini-dipetalae* (Essig), on olive. (Original.)

8. The omnivorous looper, *Sabulodes caberata* Guen. The caterpillars of this moth occasionally feed upon the leaves of the olive trees at Berkeley.

9. The larvae of a moth (Pyralid?) have been taken a number of times from the knots on the olive limbs produced by the bacteria, *Bacterium savastanoi* Smith, by Prof. W. T. Horne and Prof. Elmore Chase at Fairoaks. The soft spongy tissues as well as the

[8] Bull. 222, Cal. Agr. Exp. Sta., p. 106, 1911.
[9] Bull. 226, Cal. Agr. Exp. Sta., p. 325, 1912.

harder portions of the knots are thoroughly perforated with the burrows (fig. 13) made by the caterpillars. It does not appear to attack any other parts of the trees. The caterpillars are whitish and about one inch long. They are quite abundant, but so far no adults have been reared to determine the species.

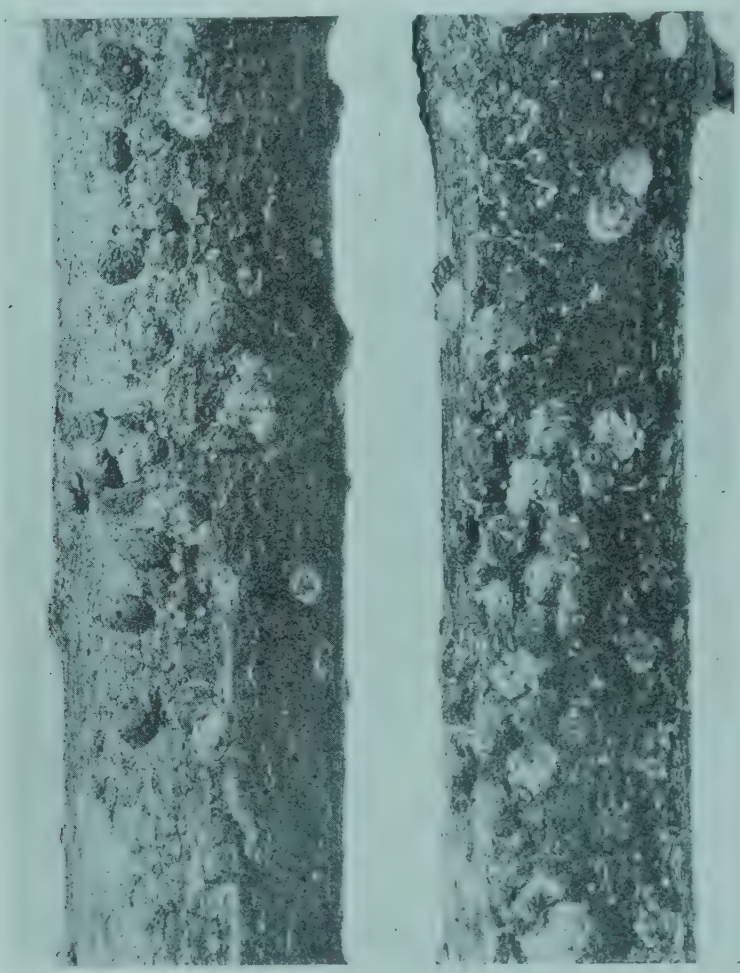

Fig. 11.—The greedy scale, *Aspidiotus camelliae* Sign., on old olive suckers. The smut fungus which partially conceals the scales is from black scale on the same tree. (Original.)

(Photo by Div. Sci. Illust., Univ. Calif.)

## SOME OF THE PRINCIPAL INSECTS ATTACKING THE OLIVE TREES IN OTHER STATES AND FOREIGN COUNTRIES

There are but few olives grown in other states of this country, consequently the list of pests on them is very short. In a number of foreign countries, however, and particularly in the Mediterranean region, where the olive has been growing for ages, the number of recorded pests is quite large. Among the many there are but few serious enough to warrant control measures. In the following list

the most important ones as well as a number of lesser importance which are most often found in published economic literature, are included so as to give some idea of the difficulties of growing olives in other districts, as well as to reflect the benefit derived from excluding these by state and national quarantine.

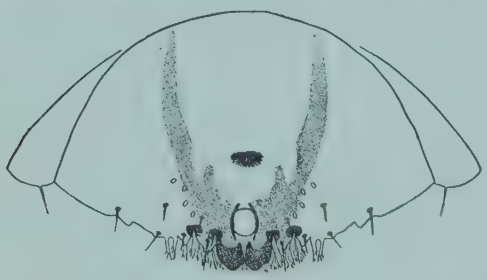

Fig. 12.—Drawing of the pygidium of the greedy scale, *Aspidiotus camelliae* Sign. Greatly enlarged. (Original.)

1. The olive thrips, *Phloeothrips oleae* (Costa) (fig. 14). This insects attacks the leaves and fruit, producing the characteristic scarring common to the thrips. It occurs throughout Southern Europe, Palestine, and South Africa and at times is a serious pest.

2. The cicada, *Tibicen cinctifer* (Uhler). The egg punctures weaken the small twigs and branches of young olive trees in the Salt River Valley, Arizona.[10]

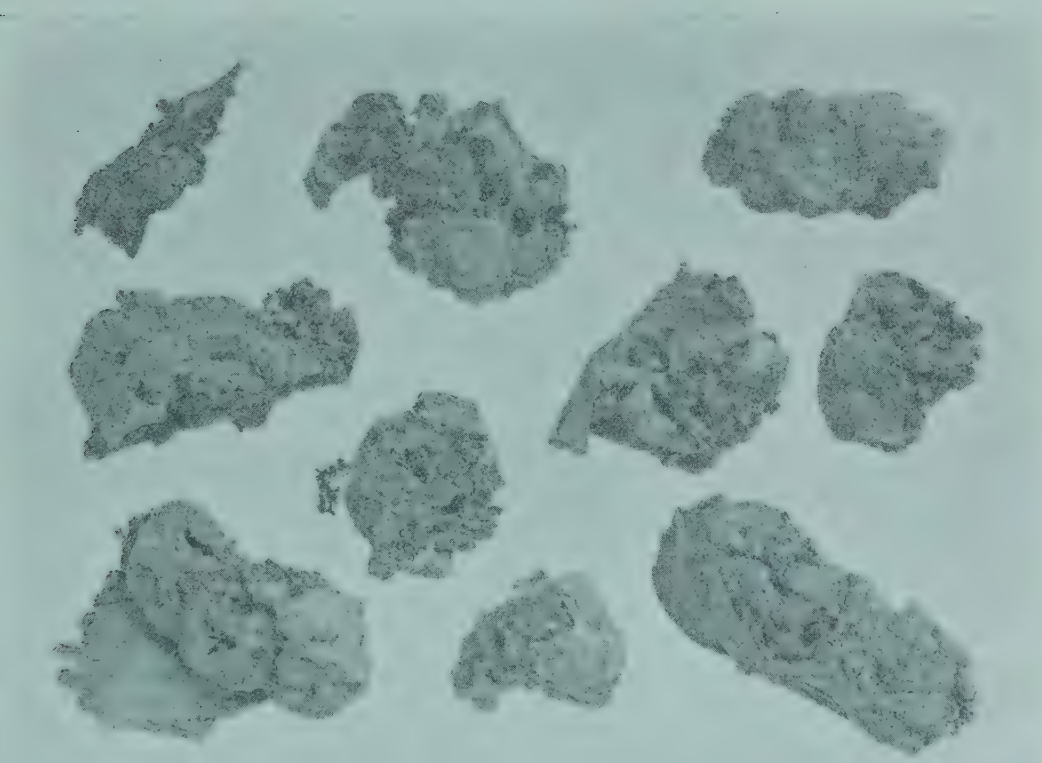

Fig. 13.—Work of a caterpillar on the olive knot at Fairoaks. (Original.)
(Photo by Div. Sci. Illust., Univ. Calif.)

[10] Morrill, Dr. A. W., 7th Ann. Rept. Com. Agric. and Hort., p. 34, 1915, *Cicada.*

3. The olive psylla, *Euphyllura olivina* (Costa) (fig. 15). This insect infests the young shoots, buds and flowers, causing the latter to drop and prevents the setting of much of the young fruit. The young psyllids are covered with a white cottony material which entirely hides them from view. It occurs throughout southern

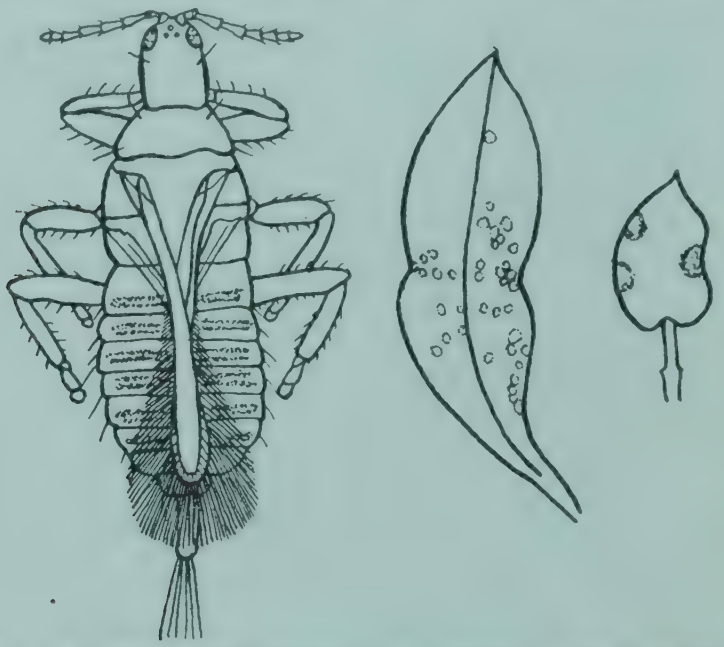

Fig. 14.—The olive thrips, *Phlocothrips olcae* (Costa). Adult female and work of the insect on leaf and fruit of the olive. (Redrawn from Del Guercio.)

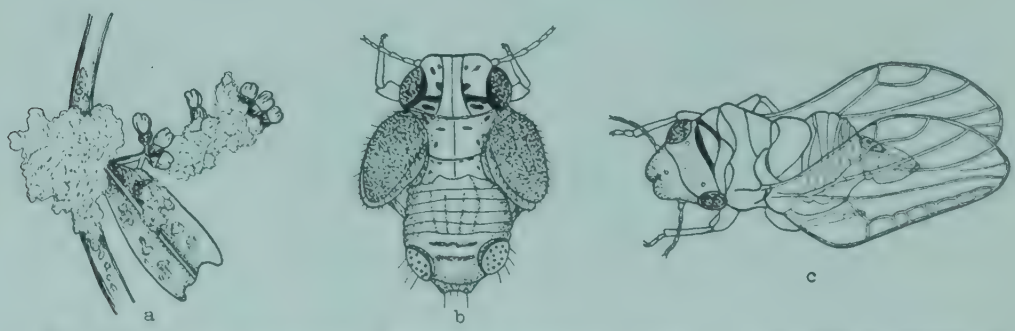


Fig. 15.—The olive psylla, *Euphyllura olivina* (Costa). *a*, colony of young on twig and flowers; *b*, nymph; *c*, adult. (Redrawn from Coutance and Del Guercio.)

Europe and in Palestine and is a pest of minor importance except in rare instances.

4. The scale, *Pollinia pollini* (Costa). A soft scale attacking the smaller branches of the olive trees in southern Europe. It was once taken on a few olive trees at Pasadena, California, which were imported from Italy in 1893. Alexander Craw at once promptly de-

stroyed the infested trees and apparently exterminated the insect.[11] Where found it is a pest of little importance.

5. The scale, *Filippia oleae* (Costa). A soft scale infesting the olive leaves in southern Europe, but not nearly so serious as the black scale, *Saissetia oleae* (Bern.) in the same localities, because it produces little honeydew and causes practically no smutting.

Fig. 16.—The olive white fly, *Aleyrodes olivinus* Silvestri. *a*, adult; *b*, nymph; *c*, row of eggs. (Redrawn from Silvestri.)

Fig. 17

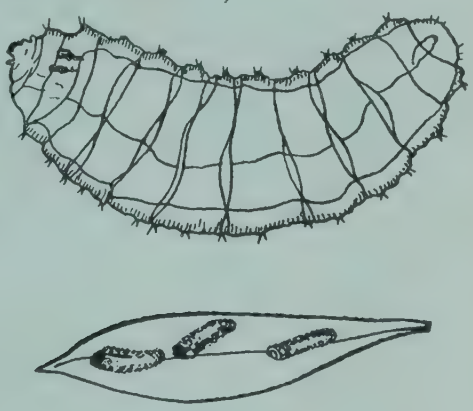

Fig .18

Fig. 17.—Adult of the bark-beetle, *Hylesinus oleiperda* (Fab.). (Redrawn from Barbey.)

Fig. 18.—The olive leaf-miner, *Perrisia oleae* Angelini. Larva and the mines on an olive leaf. (Redrawn from Del Guercio.)

6. The terrapin scale, *Lecanium nigrofasciatum* Pergrande, was reported by Pergrande as occurring on olive in Florida.[12]

7. *Leucaspis riccae* (Targ.). A scale insect commonly attacking olive trees in southern Europe and northern Africa, but of little consequence as a pest.

8. The rufous scale, *Selenaspidis articulatus* (Morgan). A scale occurring in southern Africa, West Indies and at Key West, Florida.

[11] 4th Bien. Rept. Cal. Bd. Hort., p. 438, 1894, and 5th Bien. Rept. Cal. Bd. Hort., p. 43, 1916.

[12] Bull. 18, N.S., U. S. Dept. Agr., Bur. Ent., p. 26, 1898.

It attacks citrus and olive trees and is of some importance as pest to the former.

9. The masked scale, *Chrysomphalus personatus* (Comst.). Reported by Dr. T. D. A. Cockerell as severely attacking olive trees at Kingston, Jamaica.[13]

10. The black araucaria scale, *Chrysomphalus rossi* (Mask.). There are many reports to the effect that this scale is a serious olive pest of different parts of Australia.[14] It occurs in California on *Araucaria* spp., but has shown no tendency to attack the olive here.

11. The laurel scale, *Aonidia lauri* (Bouché), is reported as seriously attacking olive trees in Chili.[15]

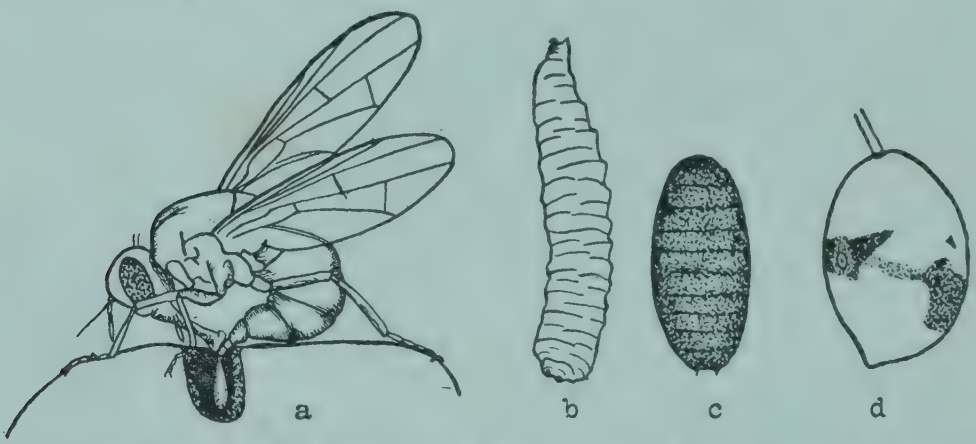


Fig. 19.—The olive fly, *Dacus oleae* Rossi. *a*, adult laying eggs in the fruit of the olive; b, maggot; c, puparium; d, olive showing egg puncture, work and exit hole of the maggot. (Redrawn from Chapelle, Ruby and Martelli.)

12. Glover's scale, *Lepidosaphes gloverii* (Pack.). Also known as the long scale. Attacks the olive in southern France and northern Africa (Tunis). It occurs in San Diego County, where it sparingly attacks citrus trees, but has never been recorded on olive in this state.

13. The scale, *Parlatoria calianthina* Berl. e Leon. Infests the olive in southern Europe. Taken on imported olive trees from Greece in quarantine at San Francisco by inspectors in 1915.[16]

14. The olive white fly, *Aleyrodes olivinus* Silvestri (fig. 16). The nymphs of this insect occur on the leaves of olive trees in central and southern Italy as well as in Spain, Tunis, and Smyrna. It is not a pest of any serious consequence.

15. The bark-beetle, *Hylesinus oleiperda* (Fab.) (fig. 17). This

[13] *Insect Life*, vol. V, p. 121, Nov., 1892.

[14] French, C., Handb. Destr. Ins. Victoria, pt. II, p. 50, 1893, and Despeissis, A., Handb. Hort. and Vit., 2nd ed., p. 576, 1903.

[15] Philippi, Dr. R. A., *Insect Life*, vol. I, p. 154, Nov., 1888.

[16] Maskew, Frederick, Mthly. Bul. Calif. Hort. Com., vol. V, p. 75, 1916.

beetle causes considerable damage in southern Europe by burrowing into the older portions and the limbs of the olive trees. It is, however, primarily a pest of unhealthy or injured trees.

16. *Phloeotribus scarabaeoides* Bern. (Syn. *P. oleae* Fabr.). Another bark-beetle which makes galleries in the branches and cuts off the small twigs by its burrows. It is a serious pest in Italy. This and the preceding beetle are closely related to the olive bark-beetle recently discovered in California and discussed in this paper.

Fig. 20.—The olive tinea, *Prays oleellus* (Fab.). *a*, caterpillar; *b*, adult; *c*, work of caterpillars in seeds; *d*, exit hole of the caterpillar in a fruit; *e*, webs and work of caterpillars on buds and blossoms; *f* and *g*, work of the caterpillars on the leaves of the olive. (Redrawn from Chapelle, Ruby, and Del Guercio.)

17. The olive weevil, *Rhynchites ruber* Fairm. The adults feed upon the tender leaves and tips of the young shoots and puncture the young fruit. The larvae live in the seeds. It does serious damage at times to the olive crop in Italy.

18. The olive leaf-miner, *Perrisia oleae* Angelini (fig. 18). A small cecidomyiid fly the maggots of which mine the leaves of the olive trees in Italy. It is of little economic importance as a pest.

19. The olive fly, *Dacus oleae* Rossi (fig. 19). This is undoubtedly the most serious pest of the olive to be found anywhere and it is very fortunate that it has never gained access to this state. It occurs in the olive-growing sections of southern Europe, Asiatic Turkey, Palestine and northern and southern Africa. The fly punctures the fruit in which it deposits its eggs and within which the larvae

or maggots live until mature. The work of the maggots results in the premature dropping of the fruit and a diminution in the yield of oil. Considerable money is spent annually by the olive growers in the control of this pest.

20. The olive tinea, *Prays oleellus* (Fab.) (fig. 20). This small moth is quite a serious pest in southern Europe and of less importance in Palestine. The caterpillars feed upon the buds, blossoms, and in the seeds of the fruit causing much loss in many cases. It is probably second in importance to the olive fly.

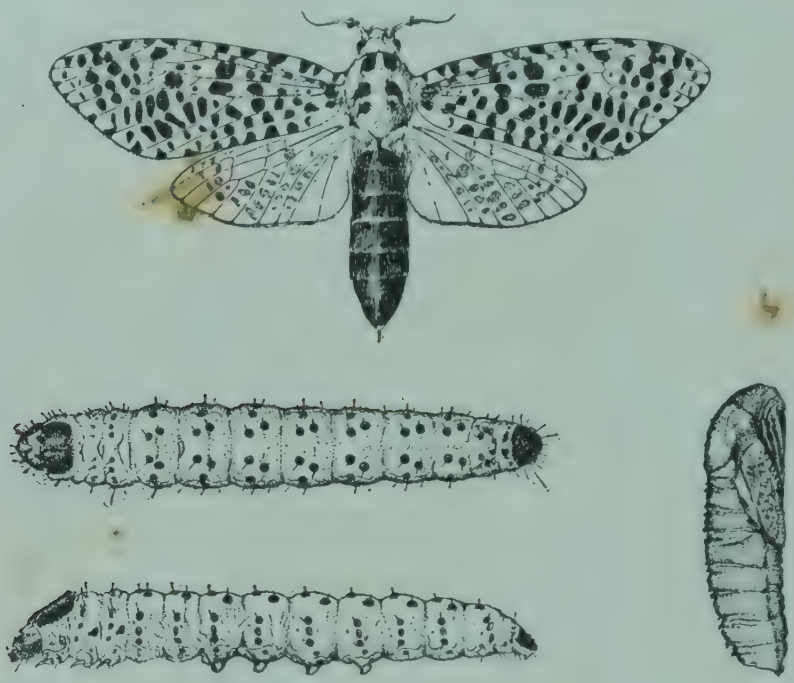

Fig. 21.—The leopard moth, *Zeuzera pyrina* (Linn.). Adult female, caterpillars and chrysalis. Natural size. (After Britton.)

21. The leopard moth, *Zeuzera pyrina* (Linn.) (fig. 21). The caterpillars of this moth bore large galleries into the wood of perfectly sound and healthy trees and do considerable damage to olive trees in southern Europe, especially in Italy. It is reported as the most serious olive pest in Palestine. It also occurs in northern and southern Africa and in Korea, Japan, and along the Atlantic seaboard from Massachusetts to the southern part of New Jersey. The insect is a very destructive pest to a large number of shade and forest trees, as well as to such cultivated fruits as apple, cherry, currant, pear, plum, and walnut. It is an insect that we might well take extra precautions to keep out of California by quarantine or other measures.[17]

[17] See Farmers' Bull. 708, U. S. Dept. Agr., Feb., 1916, Howard and Chittenden, and Bull. 169, Conn. Agr. Exp. Sta., Nov., 1911, by Britton and Cromie.

UNIVERSITY OF CALIFORNIA PUBLICATIONS

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# IRRIGATION OF ALFALFA IN IMPERIAL VALLEY

BY

WALTER E. PACKARD

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# IRRIGATION OF ALFALFA IN IMPERIAL VALLEY

By WALTER E. PACKARD

## ALFALFA IRRIGATION[1]

Recent investigations have indicated certain desirable changes in the methods of irrigating alfalfa in Imperial Valley, which, if carried out will tend to increase yields. At present the annual yields vary from two and one-half to ten tons per acre (besides winter pasturage); four and one-half tons being a fair average for the whole valley. The wide variation is due to the great difference in the character of the soils and to the fact that some fields are irrigated more efficiently than others. Alkali is a factor in the low productiveness in some cases, but taking the valley as a whole, "alkali" is not the main cause for low yields. Although it is certain that the "softer" or sandier types of soil are better adapted to alfalfa than the "harder" or heavier types, experiments have shown that careful irrigation will, in a large measure, eliminate the differences between yields obtained on these types. The number of cuttings and the yields secured from an established stand of alfalfa depend almost entirely upon the efficiency of irrigation.

### PREPARING LAND FOR IRRIGATION

A field which is to be planted to alfalfa should be especially well prepared. Any neglect in proper leveling will often cause much trouble and some loss during the entire time that the crop occupies the land, while carelessness in forming the seed bed may result in a thin stand, with the resultant introduction of Bermuda grass. The actual loss in crop area is often considerable (from 5 to 15 per cent) while the slow growth of the alfalfa on high places in the field not receiving sufficient water, represents an unnecessary financial loss to the farmer.

[1] Based in part on work done in coöperation with the Office of Public Roads and Rural Engineering, U. S. Department of Agriculture and the State Department of Engineering of California. The measurements of water applied to alfalfa fields and the field studies of its distribution in the soil and in part the examination of water-logged lands were made by F. J. Veihmeyer, Assistant Irrigation Engineer, Office of Public Roads and Rural Engineering.

Land which has never been plowed should be turned to a depth of from four to six inches, while land which has been plowed will be benefited by a deeper working. If the land is moist, discing should follow the plowing each day in order to prevent the ground surface from becoming too lumpy. The borders should be rebuilt and straightened. A thorough irrigation will indicate any irregularities in the surface which may have been overlooked. After the land is well leveled and irrigated, discing and harrowing will prepare the surface for seeding.

*Seeding.*—Alfalfa can be satisfactorily broadcasted or seeded with a drill. Experiments have so far indicated that drilling is the preferable practice, if the seed is not planted too deeply (not deeper than one-half inch in heavy soils, or one and one-half inches in light soil). Some remove the seed tubes from behind the drill discs in order to prevent this deep seeding, especially where the land is to be irrigated immediately after planting.

October is considered the best month for planting, although alfalfa can be successfully sown at almost any time between October 1 and April 15. The heavy content of silt in the irrigation water during periods in the fall is the greatest objection to fall planting, while the heavy winds often cause much trouble in the spring.

*Irrigation at the Time of Seeding.*—Irrigation of the young alfalfa is a particular operation. The soil should be well wetted by a thorough irrigation before planting. Where the seed is drilled in and not irrigated, the fields should be "planked" or dragged in order to compact the earth about the seed to insure germination. No irrigation should be given until the plants develop from three to four true leaves. Where the seed is irrigated, which is the custom in Imperial Valley, the first irrigation after planting should be followed by a second light irrigation in from three to five days. The silt carried by the irrigation water often forms an almost impenetrable crust soon after irrigation and with the harder types of soil the surface itself becomes so hard and dry for a quarter of an inch or more that the young plants cannot come through. The second irrigation recommended tends to overcome this hardening and drying and usually insures a good stand. It is important, however, that this second irrigation should come before the plants appear above the ground, on account of the fact that irrigation of the young plants with muddy water before the third or fourth true leaf appears will usually injure the seedlings, in many cases killing so large a percentage as to seriously deplete the stand. Withholding the water from the young plants after they are well sprouted will ordinarily not cause a loss.

for though the surface crust may appear very dry, the roots, which attain a penetration of from eight to fifteen inches, as shown in figure 1, within three weeks after seeding, will ordinarily carry the plants through. After the young plants have developed three or four true leaves, irrigation may proceed in the usual way.

Fig. 1.—1–2, Alfalfa Seedlings, first appearance above ground. Too young to irrigate. 3–4, Alfalfa seedlings too young to irrigate safely with silty water, particularly on heavy soils. 5–6, Alfalfa seedlings large enough to be safe from damage from silty water under ordinary conditions.

## WATER REQUIRED FOR ALFALFA

Alfalfa requires from 350 to 1000 tons of water to produce one ton of cured hay.[2] The wide variation in water requirement is due to the varying condition of humidity and temperature under which

[2] *The Soil*, by King, the MacMillan Co.; *Principles of Irrigation Practice*, by Widsoe, MacMillan Co.; *The Water Requirement of Plants*, by Briggs and Shantz, Plant Ind. Bull. 284, U. S. D. A.

the plant is grown. The fact that alfalfa grows so readily in the spring and fall with half the number of irrigations required in the hot and dry summer months, illustrates that fact.[3] In this section where the temperatures are so high and the humidity so low, transpiration is probably greater than in most alfalfa-growing sections of this country,[4] and an unusually large amount of water is required. As this report is not a study of the duty of water for alfalfa the question of the amounts used will not be discussed.

### Wilting Point—Amount of Water Necessary for Plant Growth

Not only does alfalfa require a large amount of water but the water must be applied in the right quantities in order that the plant may utilize it. It is impossible for any plant to remove all of the water from a soil on account of the adhesion of the water to the small soil particles. The fact that damp sand holds together while dry sand or sand held under water does not, illustrates this drawing power.

This wilting point varies in different soils from 2 per cent of moisure present in the coarse sands to 18 per cent in the finest clay. As the soil on any farm is a combination of distinct types, usually occurring in layers of various thicknesses, although sometimes being a more or less homogeneous mixture, the wilting coefficient of the average soil in the field is usually some combination of the figures given, as indicated by the table accompanying the soil charts, which give the wilting coefficient of the various types of soil found in the fields studied. When it is realized, however, that alfalfa planted on the sandiest types of soil in the valley would not wilt until the moisture reaches the low limit of 2 or 3 per cent, while alfalfa planted in a plat of heavy clay soil would wilt when 18 per cent of moisture is present, it can be seen that the soils found here must receive different treatment in order to get similar results.

### Saturation of the Soil not Desirable

Too much water is as undesirable as too little, for plants need air as well as moisture. Too much water usually causes the greater losses, for it necessitates drainage in many cases in addition to the loss of the crop. Although it is impossible to say just what percentage of

[3] Although the greater transpiration during the summer is probably the main cause for reduced growth during that period, the effect of the intense sunlight undoubtedly has a detrimental effect on the summer growth of the alfalfa, as pointed out by William Lawrence Balls in his book entitled *The Cotton Plant in Egypt—Studies in Physiology and Genetics*, MacMillan Co., London, 1912.

[4] No measurements have been made of the transpiration in this section, but from conclusions made by Briggs and Shantz in Plant Ind. Bull. 284, U. S. D. A., it can be assumed that transpiration is very great in this section.

moisture is needed to maintain a maximum growth of alfalfa, it is safe to conclude that the moisture content in the soil must be somewhere above the wilting point and below saturation.

### Conditions Suitable for Control of Moisture

As the rainfall in this section averages below four inches per year, the valley soils are dust-dry to a considerable depth before irrigation water is added. The moisture found in the surface soil must, therefore, come either from seepage from canals or from direct irrigation. This allows an almost perfect control of soil moisture by the irrigator

Fig. 2.—Separating alfalfa roots from soil by hand. Roots are later washed, dried and weighed.

and at the same time affords excellent conditions under which to study the problems of moisture penetration.

## GENERAL SURVEY OF EXISTING CONDITIONS

A general survey of the moisture condition in the valley soils showed a wide variation in depth of penetration, as might naturally be expected. In the hard and medium hard soils the penetration averaged about three feet, while in many cases water had not penetrated for more than two feet after two or three years of irrigation. In the medium soft soils the condition is usually good, the moisture penetrating to a depth of from ten to fifteen feet, with no excess accumulation in the lower strata. The sandy soils are commonly over-irrigated. In many places with sandy soils water stands from

two to ten feet from the ground surface, especially where the porous sand overlies impervious clay.

### Root Development

In connection with this investigation a study was made of root development in different types of soil and under varying water conditions in order to know how the feeding roots responded to irrigation. An area three feet square was selected in an average location on each field studied and the soil removed to the full depth of root penetration, agitated until all soil particles were washed away, leaving a mass of

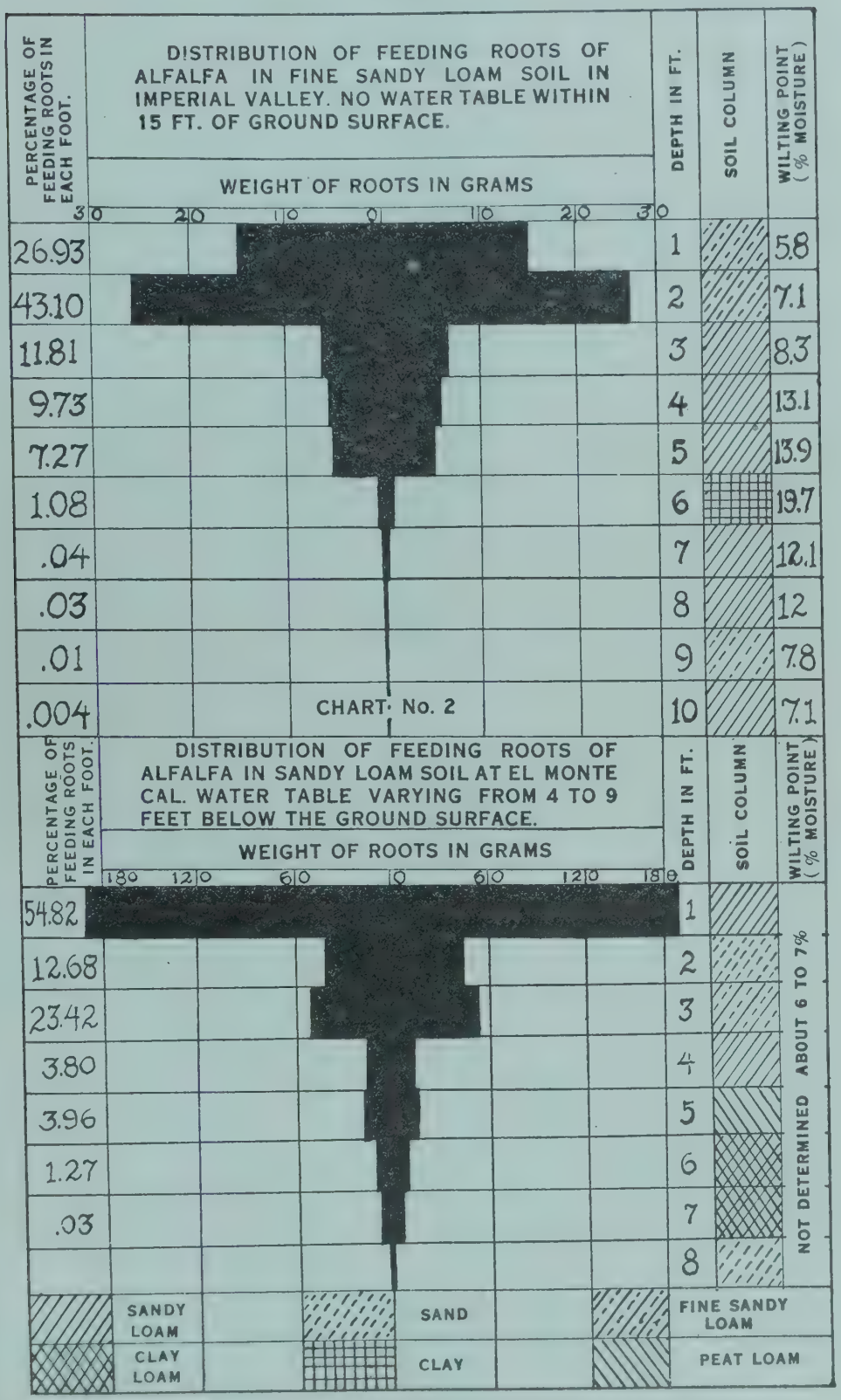
Fig. 3.—Separating soil from roots by placing soil mass in a screen box and agitating in an irrigation ditch.

roots. The roots of various sizes were sorted out and the smallest with a diameter of 1 mm. or less were rewashed, air-dried, and weighed. Charts were made representing the distribution of these roots in each foot to the full depth of root penetration. It is assumed a six-inch layer being removed at a time. The soil was placed in a screen box and the whole held under water in an irrigation ditch and that these small roots represent the feeding roots of the alfalfa and that the charts representing the distribution of these feeding roots really represent graphically the feeding zone of the alfalfa plant.

### A Large Proportion of Feeding Roots are in the Surface Soil

The most striking feature brought out by the charts is that from 80 to 90 per cent of the fine roots are found in the upper four feet

CHART No. 1


PERCENTAGE OF FEEDING ROOTS IN EACH FOOT.
DISTRIBUTION OF FEEDING ROOTS OF ALFALFA IN FINE SANDY LOAM SOIL IN IMPERIAL VALLEY. NO WATER TABLE WITHIN 15 FT. OF GROUND SURFACE.
WEIGHT OF ROOTS IN GRAMS
30 20 10 0 10 20 30
DEPTH IN FT.
SOIL COLUMN
WILTING POINT (% MOISTURE)
26.93 1 5.8
43.10 2 7.1
11.81 3 8.3
9.73 4 13.1
7.27 5 13.9
1.08 6 19.7
.04 7 12.1
.03 8 12
.01 9 7.8
.004 10 7.1
CHART No. 2
PERCENTAGE OF FEEDING ROOTS IN EACH FOOT.
DISTRIBUTION OF FEEDING ROOTS OF ALFALFA IN SANDY LOAM SOIL AT EL MONTE CAL. WATER TABLE VARYING FROM 4 TO 9 FEET BELOW THE GROUND SURFACE.
WEIGHT OF ROOTS IN GRAMS
180 120 60 0 60 120 180
DEPTH IN FT.
SOIL COLUMN
WILTING POINT (% MOISTURE)
54.82 1
12.68 2
23.42 3
3.80 4
3.96 5
1.27 6
.03 7
8
NOT DETERMINED ABOUT 6 TO 7%
SANDY LOAM
SAND
FINE SANDY LOAM
CLAY LOAM
CLAY
PEAT LOAM

where the land receives frequent surface irrigations. Deep roots can be formed by a system of deep irrigation, as described in chart No. 3 but under ordinary conditions the largest mass of feeding roots is developed in the top zone. Alfalfa has always been represented as a deep-rooted crop, which it is, but it is very apparent that, under the conditions represented by these charts, a very small percentage of the roots go below five feet. In the type of soil and under the conditions described a majority of the small roots are in the upper two feet, which fact indicates that it is very essential to give this upper zone particular attention in any system of irrigation designed to secure large yields.

### Need of Organic Matter Demonstrated

The presence of organic matter has a very noticeable effect on the development of the feeding roots, as indicated by the fact that whenever a stratum containing much organic matter is encountered the feeding roots are always very numerous. A perfect network of these fine roots gathers about a piece of decaying wood or follows down the channels left by roots of native vegetation which formerly occupied the land. The larger roots often pass through a sandy stratum containing little organic matter without sending out very many fine roots until the heavier, richer soil is reached.

This is well illustrated in chart No. 2. The fine roots were very much more numerous in this location than in any Imperial Valley soils studied. The only reasonable explanation of this fact is that the comparatively large amount of organic matter found in the El Monte soils induced this greater root development and in part accounts for the large yields secured on these non-irrigated lands.[5] The number of fine roots in the different soil strata varies with the amount of organic matter present, which accounts for the fact that in the chart more roots are indicated in the third than in the second foot and more in the fifth than in the fourth.

It is very evident that the soils of Imperial Valley need more organic matter, and anything that can be obtained to supply this need should be added whenever possible.

The charts represent so many varied conditions that each will be discussed separately.

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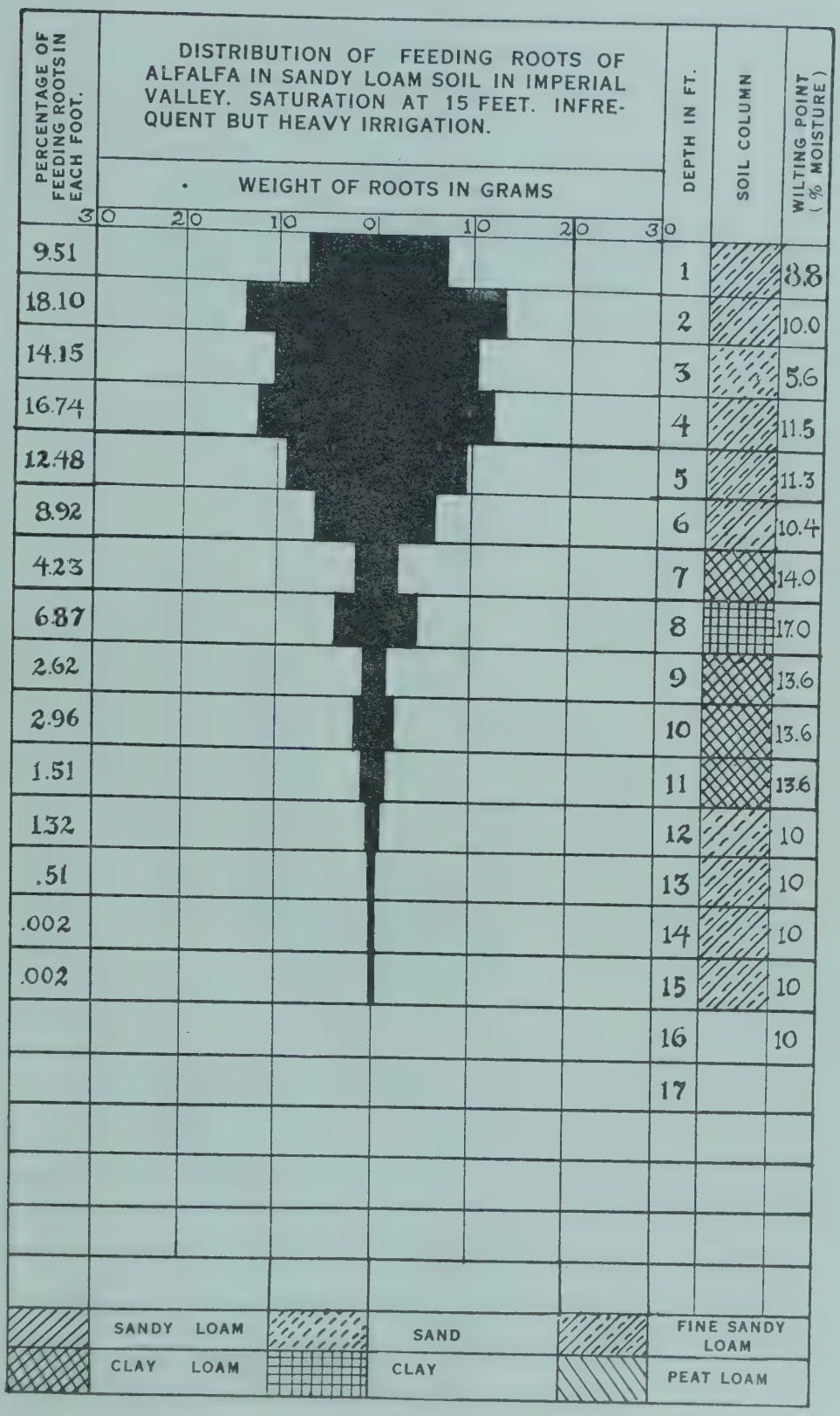
[5] The very large percentage of roots in the surface stratum, as indicated by the chart, is probably too great on account of the fact that it was impossible to separate out all of the organic material other than roots. This may have had an effect on the total quantity in these soils.

CHART No. 3


PERCENTAGE OF FEEDING ROOTS IN EACH FOOT.
DISTRIBUTION OF FEEDING ROOTS OF ALFALFA IN SANDY LOAM SOIL IN IMPERIAL VALLEY. SATURATION AT 15 FEET. INFREQUENT BUT HEAVY IRRIGATION.
WEIGHT OF ROOTS IN GRAMS
3 0 2 0 1 0 0 1 0 2 0 3 0
DEPTH IN FT.
SOIL COLUMN
WILTING POINT (% MOISTURE)
9.51 1 8.8
18.10 2 10.0
14.15 3 5.6
16.74 4 11.5
12.48 5 11.3
8.92 6 10.4
4.23 7 14.0
6.87 8 17.0
2.62 9 13.6
2.96 10 13.6
1.51 11 13.6
1.32 12 10
.51 13 10
.002 14 10
.002 15 10
16 10
17
SANDY LOAM
SAND
FINE SANDY LOAM
CLAY LOAM
CLAY
PEAT LOAM

## DISCUSSION OF CONDITIONS REPRESENTED BY THE CHARTS

Chart No. 1 represents the weights of feeding roots in each foot in depth in the field giving the highest yield of alfalfa of those studied. The alfalfa was nine years old and produced from six to nine tons per acre besides winter pasture, in an average of six cuttings. The soil is a sandy loam to a depth of five or six feet and from there to twelve feet, clay, clay loam, and sandy loam strata alternate. The greatest number of roots is in the second foot, with 95 per cent in the upper four feet, which is to be expected in a soil where all of the moisture is supplied on the surface by irrigation and none by sub-irrigation.

The moisture in this field had penetrated to a depth of more than fifteen feet. No water table existed at this depth, although the lower strata were very near the saturation point. Water was applied at more frequent intervals than on any of the fields under observation, so that the top foot of soil seldom dried out to below the wilting point, during the period between irrigations. The value of this system of frequent light irrigations is at once apparent for the roots in this field go to a depth of eleven feet, and in all of that area the percent of moisture in the soil between irrigations ranges between saturation and the wilting point, always affording ample moisture for all roots.

It seems apparent therefore that frequent irrigation, sufficiently light to prevent a water-logging of the soil and at the same time sufficient to allow for deep penetration will keep up the moisture supply in the zone of greatest root development and will as a result give the largest yields. One heavy irrigation may add as much water as two light irrigations, but in the one case much of the water will be lost by seeping below the root zone, while in the others the water will be largely retained in the top soil as available moisture for plant growth.

Chart No. 3 represents the deepest-rooted alfalfa studied. The soil is a sandy loam for a depth of six feet where a five to six-foot stratum of clay loam and clay begins. The field produces from five to six tons of alfalfa hay per year besides winter pasture. When this land was leveled a large amount of water was used which undoubtedly saturated the lower soil strata. After the alfalfa stand was about a year old the ranch was sold and no water was applied to this field for about ten months. During this time the alfalfa roots depended upon the moisture already in the soil to maintain plant growth, and as a result the feeding roots were developed in the full depth of twelve

CHART No. 4

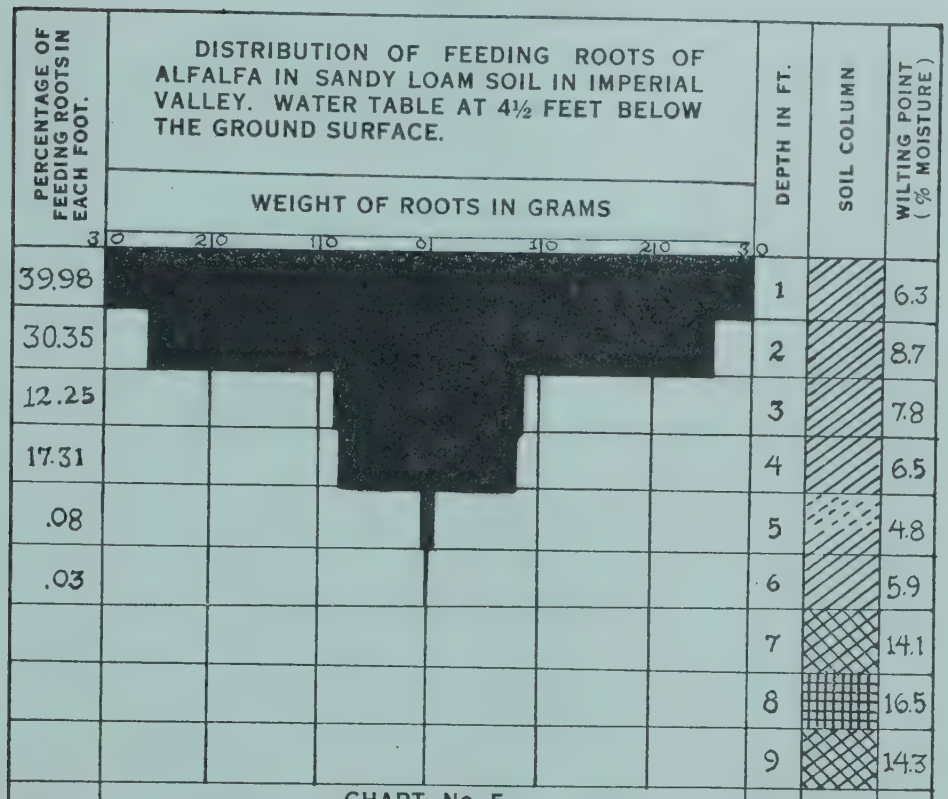
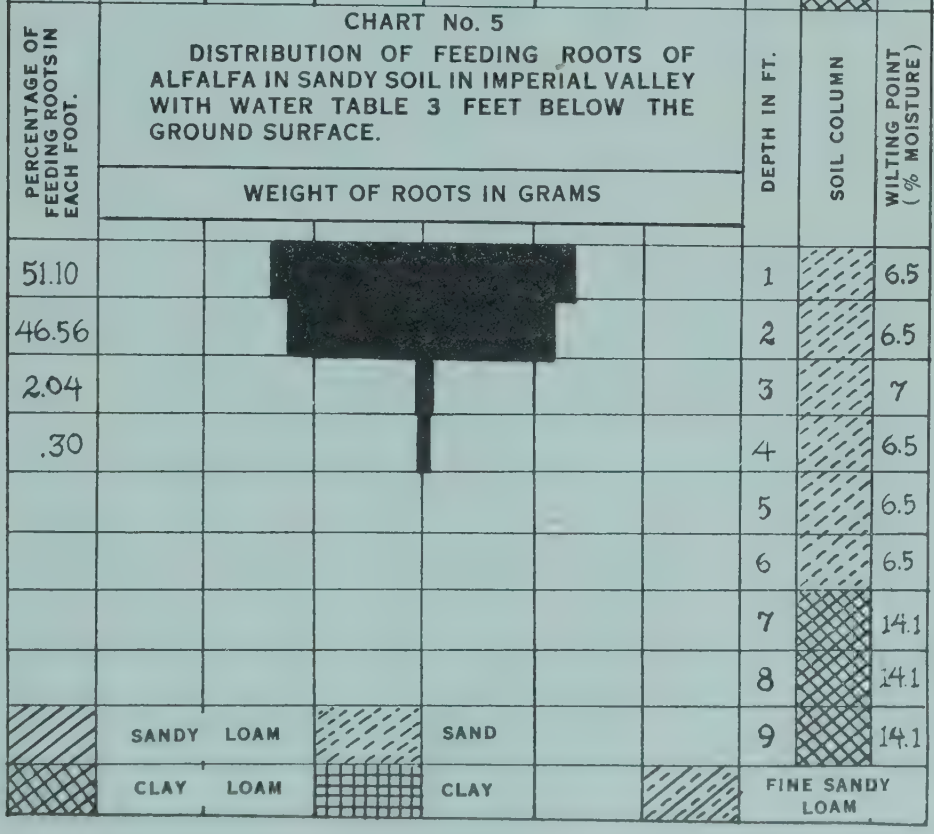

PERCENTAGE OF FEEDING ROOTS IN EACH FOOT.
DISTRIBUTION OF FEEDING ROOTS OF ALFALFA IN SANDY LOAM SOIL IN IMPERIAL VALLEY. WATER TABLE AT 4½ FEET BELOW THE GROUND SURFACE.
WEIGHT OF ROOTS IN GRAMS
3 0 2 1 0 0 1 2 3
DEPTH IN FT.
SOIL COLUMN
WILTING POINT (% MOISTURE)
39.98 1 6.3
30.35 2 8.7
12.25 3 7.8
17.31 4 6.5
.08 5 4.8
.03 6 5.9
7 14.1
8 16.5
9 14.3

CHART No. 5



feet.[6] During this period the alfalfa did not grow fast, as a majority of the feeding roots of the plant were located in the top soil where there was not sufficient moisture for plant growth, the plant maintaining itself through the roots in the moist strata below.

The condition just described is often found in sections where no irrigation water is applied to the field, but where the roots go down to water, as shown in chart No. 2. This represents the distribution of roots in a sandy soil near the San Gabriel River at El Monte, Los Angeles County, where the alfalfa is not irrigated. The El Monte field was selected to illustrate this, as no alfalfa is grown without irrigation in Imperial Valley. In this field the water table varies from four feet to nine or ten feet below the surface of the ground. In the winter, during the rainy period when the San Gabriel River is high, the water stands at the highest point.

The alfalfa makes the most rapid growth in the spring, as the rain keeps the moisture well above the wilting point at the ground surface and the water table at four feet furnishes, by capillarity, sufficient moisture for maximum plant growth in the top root zone. When the rains stop and the water table lowers, the growth slackens up and during the dry weather when the top soil is relatively dry the alfalfa does not much more than maintain itself. The fine roots which tend to follow the water down keep about even with the water plane and thus secure enough moisture to keep the plant alive and to support some growth during the summer months. In this field the roots were found to a depth of eight feet while water was encountered at nine.

### Effect of Water Table on Root Development

Much has been written regarding the dangers of a rise of water table, as large areas of good land have been rendered worthless on that account, but it seems evident from this chart and others that follow, that, where alkali is not a factor, no apparent damage is done until the water table rises above the four-foot mark or thereabouts. The roots are rotted off wherever they are submerged for any length of time,[7] and as soon as the water table rises about four feet, a sufficient number of the roots are killed to affect the plant. If water rises closer

[6] When the root studies were made the land was dry below eight feet on account of the fact that recent irrigations have not been sufficient to penetrate for more than eight feet. These lower roots, although not dead, were of no value to the plant as they were in dry soil. It is apparent, therefore, that the roots below eight feet were developed during the ten months when the substratum was saturated and no water was applied to the surface of the field.

[7] The period of submergence necessary to kill the roots is not known, except that submergence for a few days will not, but for two or three months will.

than three feet so large a proportion of roots are affected as to greatly reduce the yield by killing all but the more resistant plants. In the field just described the roots below four feet were all of this year's growth, as indicated by the fact that they branched from roots which were rotted off at the four-foot level. The lower strata were full of

Fig. 4.—Alfalfa root rotted off by rise of water table. Two small roots are shown growing from the main root after water table had lowered.

fine roots of previous years' growth which had died out with the rise of the water table.

The fact that the rise of the water table is not necessarily injurious until it begins to reach an area of large root development near the surface is indicated in charts No. 4 and No. 5. The alfalfa in the field represented by chart No. 4 is growing above a water table varying from four to six feet. As a result all of the feeding roots are in

the top four feet, the greatest number being in the top foot. This field is being damaged by the existence of a high water table, but is still producing good crops. The geld is flooded very heavily and water often stands on the alfalfa several hours before it finally disappears. The roots which had penetrated below four feet before the rise of water table were decayed, but the effect was not serious enough to kill the plants on accoount of the fact that a sufficient quantity of roots existed in the upper four feet to maintain a normal growth.

Fig. 5.—Bermuda grass soon occupies the land when alfalfa has been killed out by excessive flooding or by rise of water table.

In the field represented by chart No. 5, however, the alfalfa is rapidly dying out and Bermuda grass taking its place. The water table in this case is so close to the surface that a large majority of the roots are killed, leaving only the top two feet as a feeding zone.

It seems apparent, therefore, that, so far as the water table is concerned, alfalfa will produce large yields if the water does not come close enough to the surface to rot a large percentage of the roots. The frequent testimony, both from this section and others, that alfalfa does better with a water table at four feet than when no water table exists is probably based on the fact that a water table at that depth tends to maintain a maximum moisture condition in the top soil by

capillarity. If the water table is within three feet of the surface and remains constant, alfalfa will often produce good crops, as it does in part of the San Joaquin Valley where this condition exists, but when the water table fluctuates and sometimes rises above three feet, so large a number of roots are rotted as to greatly reduce, if not entirely kill out the stand. When alkali is present in sufficient quantities in water-logged lands, the salts tend to concentrate on the surface and often become so strong as to kill all vegetation.

### Root Development and Moisture Distribution in Clays and Clay Loams

In so-called "hard soils" the feeding roots are necessarily largely on the surface, as the irrigation water often does not penetrate for more than three to four feet. If a large yield of alfalfa is secured on this type of soil it is necessary to keep the moisture content of the top soil above the wilting point by frequent irrigations. It is apparent that if by infrequent irrigation the top foot or two dry out, the roots in that zone are of no use to the plant until further irrigation brings the water in the soil above the wilting point. This condition is very common in the valley and usually accounts for the fact that alfalfa grows slowly and often blossoms when only a foot or so high on the harder types of soil. Frequent irrigation will add the needed moisture to this top soil area, will maintain the moisture above the wilting point, and will allow for a rapid growth of alfalfa.

## GENERAL CONCLUSION

In order, then, to get satisfactory yields of alfalfa a large amount of water must be supplied during the season, it must be supplied frequently enough so as to prevent a drying of the surface soil on the one hand and water-logging of the soil on the other. This desirable condition can only be accomplished by conforming the grade of the land, the frequency of irrigation, the size of the field, and the head of water used to the types of soil to be handled. As the soil types vary widely, it will be necessary to consider each general type separately. It will be sufficient for this purpose to divide the soils of the valley into three general classes, sandy or porous soils, sandy loams or medium soft soils, and clay loam and clay or heavy soils.

## METHOD OF IRRIGATION RECOMMENDED FOR POROUS SOILS

The great danger in all sandy or porous soils is that too much water will be applied and a high water table thus formed. This condition is already prevalent in some sections, where sand overlays clay.

The clay tends to retard the downward movement of the water, and as a result there is an accumulation of water above this stratum, which gradually rises toward the surface as irrigation continues. This rise of water table can be prevented in a majority of cases by adopting one or all of the following suggestions.

*Use smaller lands.* The lands or borders for irrigation on this type of soil should usually not exceed one-eighth of a mile in length and, if necessary, not more than twenty-five to thirty feet in width in order that the water applied may reach the lower end without oversaturating the upper end. There are many fields in the valley where water has been run from a quarter to a half mile on these types of soil, with the inevitable effect of adding too much water at the upper portion of the field, which of course results in a rise of water table. The exact length and width of the lands must depend on the condition of the surface and the degree of porosity of the soil. If the soil is very sandy the lands should be both narrow and short in order to allow a quick irrigation.

*Use large head.* In addition to using smaller lands than are now being used, it would be an advantage in nearly all cases to use much larger heads of water than are at present used on this type of soil. In other parts of California a head of from eight to twelve feet is often run onto one land in order to get quick irrigation. A small head will often disappear so rapidly at the upper end that it takes a very long time to cover the field. The size of head must conform to the size of the land and the character of the soil, the point being to run the water so quickly over the land that an excess above the requirements of the plants will not be added to any part of it. A head of three to eight cubic feet per second for the very sandy soil and from two to four cubic feet per second for the more compact sandy loams would not be too great. A soil auger can be very effectively used in determining the soil moisture condition where one is uncertain regarding the moisture penetration.

In cases where the grade is less than five feet to the mile in the directions in which the lands are built, and it can be increased to a eight to ten feet to the mile by changing the direction of the lands, it should be done. There will be no danger of the soil washing at that grade and it will materially help in getting the water across the land quickly.

It is very important that the recommendations made be followed out in case of light sandy soils for there is always danger of the formation of water table when water penetration is rapid. The depth of the soil should not be considered as a safeguard, as it only takes

time to saturate the large soil reservoir. In 1910 ground water was found at a depth of fifteen feet in a field planted to alfalfa. In two years the level had raised to nine feet, so that water stood within six feet of the surface, and water is now so close to it that alkali is being brought up and deposited on the ground surface by capillary action. Every man owning "soft" land should investigate the condition in his field and conform his irrigation practice to meet the conditions present.

### Drainage is Often Necessary in Sandy Soils

In some cases a water table is formed through seepage from canals, particularly when canals are located in sandy territory on a sufficient grade to prevent a deposit of fine silt on the bottom and sides. The rate of seepage is so great under these conditions that the effect of a rise or fall in the water level in a canal can often be noticed a distance of one-eighth of a mile from the canal within twenty-four hours. This condition can only be handled by drainage or by lining the ditches causing the seepage. In most cases the ditches in the valley are on such slight grade that the deposits of silt prevent rapid seepage.

When a ranch is near a deep drain, or one of the river channels, a satisfactory system of drainage can be installed to remove the excess of water which may have accumulated by either seepage or over-irrigation. In many cases such facilities do not exist and the drainage question is a community problem which must be met as such.

A surface drain at the end of a field will be of great value in preventing a scalding of the alfalfa by standing water, although such drains do not affect the ground water condition. There is sometimes a danger of depending too much upon these drains, with the result that the lower ends of the fields are badly flooded, but where properly used much waste can be prevented. "Experience has taught the necessity of considerable depth. This should never be less than six feet—and eight feet would be a better minimum."[8] The outlet drains would have to be still deeper.

## METHOD OF IRRIGATION RECOMMENDED FOR MEDIUM SOILS

The sandy loam soils are easily irrigated, although too much or too little water is sometimes applied with the usual results. There is no good excuse, however, for not having a good moisture condition in these medium soft soils. If the alfalfa does not grow as rapidly

[8] "The Drainage of Irrigated Land," by R. A. Hart. Bulletin 190, U. S. Dept. of Agr.

as desired an investigation should be made of the moisture condition in the soil by the use of a soil augur or a spade. If the top soil appears too dry before irrigation it would perhaps be wise to give the field an additional light irrigation between cuttings. If the lower strata are saturated the recommendations given for hard or clay soils should be followed.

## METHODS OF IRRIGATION RECOMMENDED FOR COMPACT SOILS

The problem on the hard type of soils is to get the water deep into the soil in sufficient quantities to maintain rapid growth.

In many cases the fact that the surface has been irrigated is taken as evidence that the water has soaked in, while in reality only the top six inches have been wetted. It is very common to find dry soil at a depth of two and one-half to three feet in these heavy soils. In order to get proper penetration the following recommendations should be followed out.

*Size of land.* Land should be from an eighth to a quarter mile long, very seldom running one-half mile, as is now a common practice. It is difficult to handle water properly on long lands, as a flooding of the lower end can seldom be avoided. On land that is comparatively flat, borders fifty to one hundred feet apart are satisfactory, but when the land is at all steep, lands should be narrowed down to twenty-five to thirty feet wide so that a small head will cover the surface evenly.

*Head of water to use.* In order to get proper penetration, it is necessary to run a comparatively small head for a long time. Fields which yielded from two and one-half to three tons per acre per year have been made to double the yield through this system of irrigation. A small head of water requires a much longer time to travel over the field than a larger head and allows of a better penetration. Land which could be wetted only to a depth of three feet when large heads were used were successfully wetted to a depth of five and six feet by the use of smaller heads. The effect of smaller heads running for a longer time is more noticeable with furrow irrigation than with flooding, but the effect is marked in both cases.

*Grade of land.* The grade of hard land should not be over five or six feet to the mile. A grade of four feet is satisfactory if the land is properly leveled.

Drains should be made at the lower ends whenever practicable, as scalding is very common on this type of soil. The drains should be large enough to prevent the accumulation of water at the lower ends.

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# COMMERCIAL FERTILIZERS

By P. L. HIBBARD

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BENJAMIN IDE WHEELER, President of the University.

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# COMMERCIAL FERTILIZERS

By P. L. Hibbard

This bulletin comprises the results of the fertilizer inspection work of the California Fertilizer Control for the fiscal year ending June 30, 1917.

## PURPOSE AND FUNCTIONS OF THE FERTILZER CONTROL

The duty of the Fertilizer Control is:

*First:* To issue certificates of registration to manufacturers and dealers who have complied with the law by filing a sworn statement of composition and sources of the fertilizers they wish to sell.

*Second:* To analyze these fertilizers as found in the open market and publish the results for the information of the public. If a manufacturer sells fertilizers which are materially below his guarantee in composition or value he is subject to prosecution and fine. By this means it is intended to insure to purchasers that the fertilizers they buy shall be substantially as good as represented.

By a study of the reports of analyses of fertilizers, the consumer should be able to determine whether the materials he buys are sold for a fair price, and whether he obtains fertilizers of the desired composition. In short, the function of the Fertilizer Control is to see that the manufacturer gives the consumer a square deal.

## MAINTENANCE OF GUARANTEES

Every manufacturer is required by law to guarantee the percentage of nitrogen, phosphoric acid and potash in the fertilizers he sells. Owing to difficulties of sampling and analysis the law permits a maximum deficiency of 0.25% nitrogen, 1.00% phosphoric acid, 0.50% potash from the figures guaranteed. Greater deficiencies than these are regarded as infractions of the law, and are indicated in the report of analyses in black face type.

Some manufacturers uphold their guarantees better than others. The following table is a condensed report of the deficiencies found in the main table of analyses. It summarizes the work done in this laboratory on each manufacturer's goods. The columns headed *Deficiencies—per cent of possible,* may be used for comparison of the various companies as to probability of meeting their guarantees. The other columns are necessary to show how these figures were obtained. In cases where very few analyses are reported for a manufacturer, the

figures should be taken with caution, as perhaps not properly representative. When several samples of one manufacturer's goods were analyzed the figures may be accepted as probably a fair indication of the reliability of his guarantee.

In general, manufacturers have more than maintained their guarantees, so that an average of all the analyses would show a substantial increase over the amount guaranteed.

This table is a condensed statement of the analytical results on the samples of each company for the fiscal year 1916–17. A manufacturer who maintained his guarantees well last year will probably do the same this year.

MAINTENANCE OF GUARANTEES BY MANUFACTURER

| Manufacturer | Number of brands sampled | Number of samples analyze | Total number of guarantees on samples analyzed | Deficiencies | | | |
|---|---|---|---|---|---|---|---|
| | | | | In guarantees | | In valuation | |
| | | | | No. | Per cent of possible | No. | Per cent of possible |
| Agricultural Chemical Works | 13 | 62 | 128 | 12 | 9 | 3 | 5 |
| American Agricultural Chemical Co. | 7 | 24 | 68 | 0 | 0 | 0 | 0 |
| Armour Fertilizer Works | 14 | 100 | 206 | 25 | 12 | 4 | 4 |
| Rogers Brown & Co. | 5 | 13 | 25 | 9 | 36 | 8 | 62 |
| California Fertilizer Works | 3 | 5 | 8 | 2 | 25 | 2 | 40 |
| Citrus Fertilizer Co. | 3 | 10 | 29 | 2 | 7 | 1 | 10 |
| Cudahy Packing Co. | 6 | 29 | 55 | 15 | 27 | 5 | 17 |
| Diamond Fertilizer Co. | 1 | 1 | 3 | 0 | .... | .... | .... |
| Fruit Growers Supply Co. | 1 | 7 | 14 | 4 | 29 | 1 | 14 |
| Germain Seed & Plant Co. | 1 | 1 | 3 | 0 | .... | 0 | .... |
| General Fertilizer Assn. | 8 | 14 | 32 | 6 | 19 | 2 | 14 |
| Globe Grain & Milling Co. | 11 | 23 | 46 | 3 | 6 | 2 | 9 |
| Hauser Packing Co. | 4 | 27 | 53 | 16 | 30 | 11 | 41 |
| Hawaiian Fertilizer Co. | 1 | 1 | 2 | 1 | .... | 0 | .... |
| Mountain Copper Co. | 2 | 2 | 4 | 0 | .... | 0 | .... |
| Pacific Bone Coal & Fertilizing Co. | 11 | 37 | 66 | 10 | 15 | 3 | 8 |
| Pacific Guano & Fertilizer Co. | 8 | 23 | 51 | 1 | 2 | 0 | 0 |
| Pacific Reduction Co. | 2 | 3 | 9 | 0 | .... | .... | .... |
| San Antonio Meat Co. | 1 | 1 | 2 | 0 | .... | .... | .... |
| Southern California Fertilizer Co. | 1 | 14 | 52 | 1 | 2 | .... | .... |
| Standard Fertilizer Co. | 2 | 4 | 7 | 0 | 0 | 0 | 0 |
| Swift & Co. | 1 | 1 | 2 | 1 | .... | 1 | .... |
| Union Superphosphate Co. | 1 | 1 | 1 | 0 | .... | 0 | .... |
| Western Fertilizer Co. | 1 | 1 | 2 | 1 | .... | 0 | .... |
| Western Meat Co. | 9 | 70 | 124 | 17 | 14 | 7 | 10 |
| Wilson & Co., successors to Pacific Coast Beef & Provision Co. | 1 | 1 | 3 | 1 | .... | 0 | .... |

*Owing to the possibility of misunderstanding, the figures for percentage deficiencies are not given in above table in cases where less than four samples were analyzed.*

*Fertilizers sold on Station analysis, and some others, are not given a valuation in the table of analyses, hence the number of such samples is deducted from the total number analyzed, in computing deficiencies in valuation.*

## SUMMARY OF DEFICIENCIES

In the analyses of the above samples, the following number of deficiencies greater than those allowed by law occurred:

| | |
|---|---|
| Available phosphoric acid (total when available is not guaranteed) | 40 |
| Total nitrogen | 82 |
| Potash | 5 |
| In valuation | 50 |

These deficiencies were found in 126 samples.

## MECHANICAL CONDITION OF FERTILIZERS

A good degree of fineness is one of the essential qualities of a good fertilizer. It may be assumed as generally true that the finer the material the higher the availability, hence the consumer should insist on having finely ground fertilizers. Unfortunately, some manufacturers are at times careless in regard to the fineness of their goods. The insistent demand of the consumer is the most effective means of correcting such carelessness.

Besides the low agricultural availability and the difficulty in applying coarse fertilizers, it is almost impossible to obtain adequately representative samples of such goods for analysis. This is a prolific source of dissatisfaction and disagreement between buyers and sellers. During handling and transportation a coarsely ground tankage will separate so that the top of the sack contains the coarser material, high in nitrogen, while the bottom contains the finer parts of bone, high in phosphoric acid. A mixture of coarse bone meal with sulfate of potash will separate into coarse bone at the top and excess of potash at the bottom.

One of the chief reasons for the existence of the fertilizer manufacturer is that he is better prepared than the farmer to grind and mix the goods he sells, and the farmer should insist that he do it well.

## CAUTION IN REGARD TO LABELING FERTILIZER PACKAGES

The law expressly states that every package of fertilizer shall be accompanied by a plainly printed label giving the brand name, analysis, and source of the materials in the package. This requirement is

not satisfactorily met by some manufacturers and dealers. Farmers are hereby cautioned that if they buy improperly or inadequately labeled fertilizers or goods not sold by properly registered dealers or their authorized agents they may lose the protection afforded by the Fertilizer Control. Consumers should insist that fertilizer tags show plainly both the percentage and the derivation of each ingredient. A verbal statement given by the selling agent should not be accepted as adequate. The honest manufacturer is willing to guarantee his goods properly, and the farmer will best serve his own interest by dealing with no other.

### BRAND NAMES BY THE TON VERSUS POUNDS OF PLANT FOOD

Stocks of German potash salts in this country are now practically exhausted; in consequence very little potash is now being offered in fertilizers. Thus it happens that many brands of complete fertilizers once common are no longer sold, or are offered under some modified name, and carry little or no potash. Accordingly, we find many incomplete mixed fertilizers being sold. In this connection it seems pertinent to caution consumers in regard to brand names, fillers, buying by the ton, etc.

If instead of buying peach, orange, or lawn fertilizer by the ton, the consumer will buy as many pounds of nitrogen or phosphoric acid or potash as he needs or can afford, he will be much more likely to get his money's worth of plant food. On this basis, brand names and fillers have very little importance. Price per ton may be disregarded if price per pound of plant food is right. From this point of view it is seen that low percentages of plant food are nearly always high-priced. Also in buying pounds of plant food instead of tons of fertilizer, the consumer should escape the losses due to overguaranteed goods. During the past season more than the usual proportion of samples analyzed in this laboratory have failed to meet their guaranties. But this causes no loss to the farmer who pays for fertilizer on the unit basis, that is, for pounds of actual plant food delivered.

### FERTILIZER VALUATIONS

The calculations of the commercial values of the fertilizers here reported are made on the so-called unit basis. Such calculations consist simply in multiplying the number of per cent of each ingredient by the price per unit and adding the products. The sum thus obtained is the commercial value per ton at the prices used. If it is desired to use such calculation for determining the amount which should be paid for goods, or the rebate to which the buyer is entitled

owing to the goods delivered being below the guaranty, it can only be satisfactorily done if a definite price per unit has been agreed upon between buyer and seller. But for the mere purpose of showing the relative values of goods to guaranties, it is not at all necessary that the prices adopted should be the exact market prices. Thus it is that the Fertilizer Control in attempting to show the relation between values found and values claimed, uses a schedule which is admittedly only an approximate average of market values. Owing to market fluctuations, differences in cost of delivery at different points, and other causes, the obtaining of true average market prices is an impossibility. But if the reader will bear in mind the true purpose of the valuations reported, these will have served their turn and he will not be led to assume that the Experiment Station is dictating the prices at which goods shall be sold. Valuations thus construed should serve two purposes.

(*a*) To show whether a certain fertilizer is commercially worth its cost.

(*b*) As a measure for comparing the commercial values of different brands, thus enabling the buyer to select that brand which will give him the greatest value for the money he spends.

## NOTE IN REGARD TO SCHEDULE OF VALUES

In view of the recent extraordinary increases in prices of fertilizers and of the chaotic condition of the market, we find it impossible to prepare a schedule of prices by consultation of market reports as heretofore. Inasmuch, however, as such a schedule is necessary for comparative purposes, the following table of values has been prepared, based chiefly on known prices of recent sales in this State. These values are not to be taken as in any way representing actual present market prices, though they may sometimes approximate them. In the table of analyses the column "Value per ton" is given on the basis of station prices.

## SCHEDULE OF VALUES FOR 1917–1918

| | Per pound | Per unit |
|---|---|---|
| Nitrogen from blood | $0.26 | $5.20 |
| Nitrogen from tankage and bone | .24 | 4.80 |
| Nitrogen from sulphate of ammonia | .24 | 4.80 |
| Nitrogen from nitrate of soda | .24 | 4.80 |
| Phosphoric acid, available from rock super | .06 | 1.20 |
| Phosphoric acid, total from bone or tankage | .06 | 1.20 |
| Potash, water soluble | .10 | 2.00 |

## SCOPE OF INSPECTION

During the year 506 samples of fertilizers and fertilizing materials have been received at this laboratory. Of this number five were sent by farmers under the two-dollar fee provision, 203 were taken by inspectors from purchasers' goods upon the request of the purchasers, and 257 were taken by inspectors from goods in the hands of agents and manufacturers. On two samples the analysis as reported was used as a basis of settlement by mutual agreement of buyer and seller.* No guaranty was required or given with goods sold under such agreement. Thirty-one samples of a miscellaneous nature are omitted from the tables.

The following classification may be made of samples reported in this bulletin:

| | |
|---|---|
| Bat guano | 3 |
| Bird guano | 1 |
| Blood | 59 |
| Bone meal | 52 |
| Complete fertilizer | 107 |
| Cottonseed meal | 2 |
| Garbage tankage | 19 |
| Incomplete mixed fertilizer | 65 |
| Nitrate of lime | 1 |
| Nitrate of soda | 11 |
| Sulphate of ammonia | 10 |
| Superphosphate | 9 |
| Tankage | 136 |

## REGISTERED MANUFACTURERS AND DEALERS

The following manufacturers and dealers in commercial fertilizers have obtained certificates of registration under the provisions of the California fertilizer law, for the fiscal year beginning July 1, 1916. A list is also given of the brands of fertilizers and fertilizer materials offered for sale by them. According to the sworn returns of dealers registered for the fiscal year ending June 30, 1916, their entire sales in the state amounted to 29,415 tons. Incomplete returns for the year ending June 30, 1917, indicate approximately 36,000 tons.

No dealer or manufacturer, except those who have certificates of registration from the University of California, and their authorized agents, can legally sell fertilizers in this state. No person or company has any right to use any registration number except in connection with the firm name to which the registration certificate of such num-

*Besides these a considerable number of the remaining purchasers' analyses were doubtless used subsequently as a basis of settlement, but without being reported to this office.

ber has been issued; and no person or company to whom a registration number has been assigned has any right to give any other person or company permission to use said registration number; any number so used is a fraud. No agent has any right to use his principal's registration number in connection with his own name.

The total number of brands registered by manufacturers was 270, of which 118 brands, equal to 44 per cent of the total, were found on the market by inspectors and analyzed.

**Agricultural Chemical Works, Los Angeles, Cal.**

REGISTRATION No. 8

Bat Guano
Blood
Bone Meal
Brands A, B, C, K
Cottonseed Meal
Fish Guano
Gypsum
Lawn and Rose
Nitrate of Soda
Nursery
Potash Salts
Sulphate of Ammonia
Superphosphate
Tankage
Special mixture to order of consumers

**American Agricultural Chemical Co., California Works, Los Angeles, Cal.**

REGISTRATION No. 1

Acid Phosphate
Blood
Bradley's California Vegetable
Bradley's Hay and Grain No. 1
Bradley's Hay and Grain No. 2
Bradley's Lawn
Bradley's Lemon Tree
Bradley's Nursery Stock
Bradley's Orange and Lemon
Bradley's Special Nursery Stock
Bradley's Tree and Vine
Fish Meal
Nitrate of Soda
Raw Mineral Phosphate Rock
Sulphate of Ammonia
Sulphate of Potash
Tankage
Special brands to order

**Anaheim Beef & Provision Co., Anaheim, Cal.**

REGISTRATION No. 88

Blood
Bone Meal
Tankage

**Armour Fertilizer Works, Los Angeles, Cal.**

REGISTRATION No. 7

Armour 1916 Fall Brand
Blood
Bone, Blood and Potash
Bone Meal
Cottonseed Meal
Cropmaker
Flower and Fern
Fruit and Vine
Fruit Special
Guano
Lawn and Garden
Lawn Special
Nitrate of Soda
Olive Special
Orange Tree Manure
Orange Tree Special
Sheep Manure
Special 2–17–10

Special 2–20–3
Special 3–20–3
Superphosphate
Sulphate of Ammonia
Sulphate of Potash
Tankage
Vegetable Grower
Vegetable Special
Special brands to order of consumers

**Rogers Brown & Co., Los Angeles, Cal.**

REGISTRATION No. 85

Blood
Bone Meal
Fish Meal
Salmon Meal
Tankage
Whale Bone Meal
Whale Meat and Blood
Whale Meat and Bone

**California Fertilizer Works, San Francisco, Cal.**

REGISTRATION No. 3

Blood
Bone, Blood Meal
Bone, Blood Superphosphate
Bone Meal
Nitrate of Soda
Sulphate of Ammonia
Special Nursery Stock

**Citrus Fertilizer Co., Los Angeles, Cal.**

REGISTRATION No. 87

Blood
Bone Meal
Doty's Fruiting
Doty's Nursery
Doty's Special No. 1
Doty's Special No. 2
Fish
Guano
Nitrate of Soda
Sulphate of Ammonia
Sulphate of Potash
Superphosphate
Tankage
Special brands to order

**Cudahy Packing Co., Los Angeles, Cal.**

REGISTRATION No. 79

Bone Meal
Garden and Truck Grower
High Grade Blood
High Grade Fish Meal
High Grade Tankage
High Grade Tankage A, B, C, D, E
Low Grade Blood
Low Grade Tankage A
Sheep Manure
Special Lawn Fertilizer
Tankage Formula

**Fruit Growers Supply Co., Los Angeles, Cal.**

REGISTRATION No. 90

Various materials sold under names descriptive of their composition.

**General Fertilizer Association, San Bernardino, Cal.**

REGISTRATION No. 42

G. F. A. Special No. 2
G. F. A. Special No. 5
Orange No. 1
Special mixtures to order of consumers

**Germain Seed & Plant Co., Los Angeles, Cal.**

REGISTRATION No. 76

Nuvida Blood and Bone
Nuvida Flower and Fern
Nuvida Lawn and Garden Fertilizer
Nuvida Vegetable Fertilizer

**Globe Grain & Milling Co., Los Angeles, Cal.**

REGISTRATION No. 83

Bat Guano
Blood
Bone Meal
Cottonseed Meal
Fish Meal
Garbage Tankage
Nitrate of Soda
Packing House Tankage
Sulphate of Ammonia
Superphosphate
Whale Blood
Whale Bone Meal

**Hauser Packing Co., Los Angeles, Cal.**

REGISTRATION No. 33

High Grade Blood
High Grade Tankage
Low Grade Tankage
Nitrate of Soda
Steam Bone Meal
Sulphate of Potash
Special mixtures to order of consumers

**Hawaiian Fertilizer Co., Ltd., San Francisco, Cal.**

REGISTRATION No. 19

Bone Meal
Delta No. 1
Double Manure Salts
Dry Ground Blood
Fish Guano
Florin Strawberry
Florin Fruit and Vine
Fruit and Vine
Fruiting
Lawn
Lime Nitrogen
Muriate of Potash
Nitrate of Lime
Nitrate of Soda
Nursery
Special Fall
Special Spring
Sulphate of Ammonia
Sulphate of Potash
Superphosphate
Tankage
Vegetable
Whale Guano

**Thomas Lewis, Sacramento, Cal.**

REGISTRATION No. 40

The Tom Lewis Fertilizer

**Mountain Copper Co., San Francisco, Cal.**

REGISTRATION No. 28

Mococo Superphosphate 0–17–0
Mococo 0–14–9
Mococo 3–10–2
Mococo 3–10–5
Mococo 4–10–4
Mococo 4.1–10–1.5
Nitrate of Soda
Sulphate of Potash
Special mixtures to order of consumer

**Oakland Meat & Packing Co., Emeryville, Cal.**

REGISTRATION No. 24

"Special"

**Pacific Bone, Coal & Fertilizing Co., San Francisco, Cal.**

REGISTRATION No. 14

Arborette No. 1
Arborette No. 2
Blood
Bone Meal
Ceres Brand
Citrona Brand No. 1
Citrona Brand No. 2
Citrona Brand No. 3

Citrona Brand No. 4
Flora Brand
Lime Nitrogen
Lucerna
Lupin Brand
Nitrate of Soda
Pomona Brand
Pomona Brand No. 2
Potash Salts
Superphosphate
Tankage
Special Formulas

**Pacific Guano & Fertilizer Co., San Francisco, Cal.**

REGISTRATION No. 4

Brand AJX
Brand CJV
Brand F&V
Brand GG
Brand HOP
Brand IXL
Brand N
Brand OK
Brand PNK
Brand PP
Brand S
Brand TRK
Brand VGR
Brand XLT
Chapman Fall Application
Chapman Fall Application Special
Chapman Spring Application
Gromore
Superphosphate Cresco
Superphosphate Pacific
Special mixtures to order of consumers

**Pacific Reduction Co., Los Angeles, Cal.**

REGISTRATION No. 86

Cobwell Organic Meal, derived from garbage.

**San Antonio Meat Co., Pomona, Cal.**

REGISTRATION No. 69

Tankage

**Southern California Fertilizer Co., Los Angeles, Cal.**

REGISTRATION No. 89

Garbage Tankage

**Standard Fertilizer Co., Los Angeles, Cal.**

REGISTRATION No. 60

Fish Meal
Lawn Fertilizer
Nitrate of Soda
Special Potato
Standard No. 3
Standard No. 8
Superphosphate

**Swift & Co., Chicago, Ill.**

REGISTRATION No. 5

Swift's Diamond C
Swift's Diamond D
Swift's Diamond E
Swift's Diamond K
Swift's Diamond L
Swift's High Grade Blood
Swift's High Grade Tankage
Swift's Special Bone Meal

**Union Fertilizer Co., Los Angeles, Cal.**

REGISTRATION No. 9

Blood
Bone Meal
Fish Scrap
Fruiting Fertilizer
Guano
Nitrate of Lime
Nitrate of Soda
Nursery Fertilizer
Phosphate Rock
Potato Fertilizer
Special Fruiting Fertilizer
Sugar Beet Fertilizer
Sulphate of Potash
Superphosphate
Tankage
Walnut Fertilizer
Special to order

**Union Superphosphate Co., San Francisco, Cal.**

REGISTRATION No. 31

Superphosphate, Cresco
Superphosphate, Pacific

**Western Fertilizer Co., San Francisco, Cal.**

REGISTRATION No. 68

Wizard
Wonder

**Western Meat Co., San Francisco, Cal.**

REGISTRATION No. 11

Brands A, B, C, D, E, F, G, H, I, K, L, M, O, R, S
Lemon Special
Special brands to order

**Wilson & Company, Los Angeles, Successors to the Pacific Coast Beef & Provision Co., Los Angeles, Cal.**

REGISTRATION No. 64

Blood
Bone Meal
Tankage
William H. Brown Fertilizer

(See page 166 for explanation of the following Table of Analysis.)

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Agricultural Chemical Works, Los Angeles, Cal.** | | |
| 6588 | "B" | J. M. Webster, Upland | $30.80 |
| | *Guaranteed* | | *30.00* |
| 7006 | Bird Guano | W. H. Collins, Covina | 43.79 |
| | *Guaranteed* | | *43.39* |
| 6587 | Blood | J. M. Webster, Upland | 62.93 |
| 6644 | Blood | W. H. Collins, Covina | 63.25 |
| | *Guaranteed* | | *63.62* |
| 6710 | Blood | J. D. Spenetta, Orange | 63.66 |
| | *Guaranteed* | | *62.10* |
| 6841 | Blood | J. M. Webster, Upland | 63.94 |
| | *Guaranteed* | | *64.40* |
| 6571* | Bone Meal | G. A. Herdeg, Riverside | 40.17 |
| | *Guaranteed* | | *37.90* |
| 6576* | Bone Meal | E. A. Moore, Redlands | 40.04 |
| 6772* | Bone Meal | Union Commission Co., Santa Barbara | 38.80 |
| | *Guaranteed* | | *38.30* |
| 6623* | Bone Meal | S. G. Rossiter, Rialto | 40.25 |
| 6875* | Bone Meal | G. A. Herdeg, Riverside | 36.73 |
| | *Guaranteed* | | *37.00* |
| 6642* | Bone Meal | W. H. Collins, Covina | 38.78 |
| | *Guaranteed* | | *36.60* |
| 6589 | "C" | J. M. Webster, Upland | 34.43 |
| 6643 | "C" | W. H. Collins, Covina | 32.05 |
| | *Guaranteed* | | *33.80* |
| 6582 | Cotton Seed Meal | E. A. Moore, Redlands | 36.01 |
| | *Guaranteed* | | *35.60* |
| 6755 | "F" | J. D. Spenetta, Orange | 25.12 |
| | *Guaranteed* | | *23.80* |
| 6590 | "K" | J. M. Webster, Upland | 27.52 |
| 6756 | "K" | J. D. Spenetta, Orange | 27.51 |
| | *Guaranteed* | | *27.40* |
| 6754 | "L" | J. D. Spenetta, Orange | 27.57 |
| | *Guaranteed* | | *26.60* |
| 6753 | Nitrate of Soda and Bone | J. D. Spenetta, Orange | **54.84** |
| | *Guaranteed* | | *57.45* |
| 6566 | Special | Harold Latimer, Ontario | 28.75 |
| 6570 | Special | G. A. Herdeg, Riverside | 28.55 |
| 6595 | Special | J. M. Webster, Upland | 28.98 |
| 6639 | Special | W. H. Collins, Covina | 30.25 |
| 6739 | Special | J. E. Gowen, Santa Ana | 29.80 |
| 6757 | Special | Anaheim Citrus Fruit Assn., Anaheim | 29.87 |
| 6825 | Special | R. T. Nelson, Upland | 29.64 |
| 6826 | Special | J. M. Webster, Upland | 29.33 |
| 7048 | Special | R. T. Nelson, Upland | 30.18 |
| | *Guaranteed* | | *29.80* |

*6571— 46% fine. *6623— 46% fine.
*6576— 48% fine. *6875—43% fine.
*6772—100% fine. *6642—52% fine.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | |
| 6588 | 3.25 | 3.90 | 7.15 | ..... | 1.04 | ..... | 4.17 | ..... | 5.21 | ..... | 2.06 | 1.50 |
| ..... | *4.00* | *4.00* | *8.00* | *Bn, Super, T* | *2.00* | ..... | *3.00* | *Bat G, Bl, Bn* | *5.00* | *2.00* | *2.00* | ..... |
| 7006 | ..... | ..... | 15.40 | ..... | ..... | 3.11 | 3.71 | ..... | 6.82 | ..... | 1.79 | ..... |
| ..... | ..... | ..... | *14.00* | ..... | ..... | ..... | *6.60* | ..... | *6.60* | ..... | *1.75* | ..... |
| 6587 | ..... | ..... | ..... | ..... | ..... | ..... | 13.68 | ..... | 13.68 | ..... | ..... | ..... |
| 6644 | ..... | ..... | ..... | ..... | ..... | ..... | 13.75 | ..... | 13.75 | ..... | ..... | ..... |
| | | | | | | | *13.83* | ..... | *13.83* | ..... | ..... | ..... |
| 6710 | ..... | ..... | ..... | ..... | ..... | ..... | 13.84 | ..... | 13.84 | ..... | ..... | ..... |
| | | | | | | | *13.50* | ..... | *13.50* | ..... | ..... | ..... |
| 6841 | ..... | ..... | ..... | ..... | ..... | ..... | 13.90 | ..... | 13.90 | ..... | ..... | ..... |
| | | | | | | | 14.00 | ..... | 14.00 | ..... | ..... | ..... |
| 6571 | ..... | ..... | 24.30 | ..... | ..... | ..... | 4.16 | ..... | 4.16 | ..... | ..... | ..... |
| ..... | ..... | ..... | *25.00* | ..... | ..... | ..... | *3.50* | ..... | *3.50* | ..... | ..... | ..... |
| 6576 | ..... | ..... | 24.00 | ..... | ..... | ..... | 4.19 | ..... | 4.19 | ..... | ..... | ..... |
| 6772 | ..... | ..... | 24.00 | ..... | ..... | ..... | 3.91 | ..... | 3.91 | ..... | ..... | ..... |
| ..... | ..... | ..... | *23.00* | ..... | ..... | ..... | *4.00* | ..... | *4.00* | ..... | ..... | ..... |
| 6623 | ..... | ..... | 23.70 | ..... | ..... | ..... | 4.30 | ..... | 4.30 | ..... | ..... | ..... |
| 6875 | ..... | ..... | **21.50** | ..... | ..... | ..... | 3.95 | ..... | 3.95 | ..... | ..... | ..... |
| ..... | ..... | ..... | *24.00* | ..... | ..... | ..... | *3.50* | ..... | *3.50* | ..... | ..... | ..... |
| 6642 | ..... | ..... | **24.80** | ..... | ..... | ..... | 3.74 | ..... | 3.74 | ..... | ..... | ..... |
| ..... | ..... | ..... | *26.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 6589 | 3.66 | 4.44 | 8.10 | ..... | 2.67 | ..... | 3.24 | ..... | 5.91 | ..... | 2.74 | 1.32 |
| 6643 | 3.92 | 4.18 | 8.10 | ..... | 2.31 | ..... | 3.05 | ..... | 5.36 | 2.56 | 2.56 | 0.85 |
| ..... | *4.00* | *4.00* | *8.00* | *Bn, Super, T* | *3.00* | ..... | *3.00* | *Bat G, Bl, Bn* | *6.00* | *2.00* | *2.00* | ..... |
| 6582 | ..... | ..... | **3.35** | ..... | ..... | ..... | 7.09 | ..... | 7.09 | ..... | 1.80 | ..... |
| ..... | ..... | ..... | *5.00* | ..... | ..... | ..... | *6.75* | ..... | *6.75* | ..... | *1.40* | ..... |
| 6755 | 5.09 | 2.86 | 7.95 | ..... | 1.36 | ..... | 1.91 | ..... | 3.27 | 4.39 | 4.39 | ..... |
| ..... | *6.00* | *2.00* | *8.00* | *Bn, Super, T* | *1.00* | | *2.00* | *Bat G, Bl, Bn* | *3.00* | *4.00* | *4.00* | ..... |
| 6590 | **4.77** | 5.38 | 10.15 | ..... | 1.32 | ..... | 2.57 | ..... | 3.89 | ..... | 2.06 | 1.55 |
| 6756 | **4.35** | 5.60 | 9.95 | ..... | 1.34 | ..... | 2.56 | ..... | 3.90 | 2.20 | 2.20 | ..... |
| ..... | *6.00* | *4.00* | *10.00* | *Bn, Super, T* | *2.00* | ..... | *2.00* | *Bat G, Bl, Bn* | *4.00* | *2.00* | *2.00* | ..... |
| 6754 | 5.63 | 5.42 | 11.05 | ..... | 0.69 | ..... | 2.14 | ..... | 2.83 | 5.59 | 5.59 | 0.72 |
| ..... | *5.00* | *5.00* | *10.00* | *Bn, Super, T* | *1.00* | ..... | *2.00* | *Bat G, Bl, Bn* | *3.00* | *5.00* | *5.00* | ..... |
| 6753 | ..... | ..... | 1.70 | ..... | 13.80 | ..... | 0.23 | ..... | 14.03 | ..... | ..... | ..... |
| ..... | ..... | ..... | *0.50* | *Bn* | ..... | ..... | | ..... | *15.00* | ..... | ..... | ..... |
| 6566 | ..... | ..... | 9.10 | ..... | 1.75 | ..... | 3.10 | ..... | 4.85 | ..... | ..... | ..... |
| 6570 | ..... | ..... | 9.40 | ..... | 1.50 | ..... | 3.27 | ..... | 4.77 | ..... | ..... | ..... |
| 6595 | ..... | ..... | 9.85 | ..... | 1.53 | ..... | 3.25 | ..... | 4.78 | ..... | ..... | ..... |
| 6639 | ..... | ..... | 9.95 | ..... | 0.95 | ..... | 1.02 | ..... | 1.97 | ..... | ..... | ..... |
| 6739 | ..... | ..... | 9.85 | ..... | 0.83 | ..... | 4.04 | ..... | 4.87 | ..... | ..... | ..... |
| 6757 | ..... | ..... | 9.80 | ..... | 1.80 | ..... | 3.23 | ..... | 5.03 | ..... | ..... | ..... |
| 6825 | ..... | ..... | 11.05 | ..... | 2.15 | ..... | 2.62 | ..... | 4.77 | ..... | ..... | ..... |
| 6826 | ..... | ..... | 10.15 | ..... | 1.62 | ..... | 3.19 | ..... | 4.81 | ..... | ..... | ..... |
| 7048 | ..... | ..... | 10.80 | ..... | 1.84 | ..... | 3.06 | ..... | 4.90 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | *Bn, Super, T* | *2.00* | ..... | *3.00* | *Bat G, Bl, Bn, Fs* | *5.00* | ..... | ..... | ..... |

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Agricultural Chemical Works** (*Continued*). **Los Angeles, Cal.** | | |
| 6569 | Special | G. A. Herdeg, Riverside | 32.97 |
| 6580 | Special | E. A. Moore, Redlands | 34.31 |
| 6594 | Special | J. M. Webster, Upland | 34.31 |
| 6827 | Special | J. M. Webster, Upland | 34.73 |
| 6852 | Special | G. A. Herdeg, Riverside | 34.60 |
| 6876 | Special | G. A. Herdeg, Riverside | 34.03 |
| 6877 | Special | G. A. Herdeg, Riverside | 33.82 |
| | *Guaranteed* | | *34.20* |
| 6577 | Special | E. A. Moore, Redlands | 28.91 |
| 6592 | Special | J. M. Webster, Upland | 29.17 |
| | *Guaranteed* | | *27.60* |
| 6579 | Special | E. A. Moore, Redlands | 38.75 |
| 6640 | Special | W. H. Collins, Covina | 38.02 |
| | *Guaranteed* | | *40.60* |
| 6581 | Special | E. A. Moore, Redlands | 27.32 |
| 6593 | Special | J. M. Webster, Upland | 28.06 |
| 6738 | Special | J. E. Gowen, Santa Ana | 27.34 |
| 6829 | Special | J. M. Webster, Upland | 28.49 |
| 7043 | Special | I. W. Shirley, Upland | 27.40 |
| | *Guaranteed* | | *27.20* |
| 6583* | Special | E. A. Moore, Redlands | **59.96** |
| | *Guaranteed* | | *63.60* |
| 6584* | Special | E. A. Moore, Redlands | **59.03** |
| | *Guaranteed* | | *61.50* |
| 6621 | Special | S. G. Rossiter, Rialto | 23.81 |
| | *Guaranteed* | | *24.00* |
| 6622 | Special | S. G. Rossiter, Rialto | 24.93 |
| | *Guaranteed* | | *23.70* |
| 6637 | Special | H. L. Hostetler, Covina | 36.82 |
| 6638 | Special | R. M. Douglas, Covina | 37.75 |
| | *Guaranteed* | | *37.70* |
| 6813 | Special | E. A. Moore, Reedlands | 37.89 |
| 6828 | Special | J. M. Webster, Upland | 38.46 |
| 7003 | Special | W. H. Collins, Covina | 38.41 |
| | *Guaranteed* | | *37.10* |
| 6843 | Special | J. M. Webster, Upland | 39.82 |
| 7004 | Special | W. H. Collins, Covina | 41.82 |
| | *Guaranteed* | | *40.00* |
| 6851 | Special | G. A. Herdeg, Riverside | 38.36 |
| | *Guaranteed* | | *40.00* |
| 7005 | Special | W. H. Collins, Covina | 30.70 |
| | *Guaranteed* | | *31.60* |

*6583—Sample possibly not valid. *6584—Sample possibly not valid.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | Chlorin |
| 6569 | ..... | ..... | 9.35 | ..... | 1.68 | ..... | 4.13 | ..... | 5.81 | ..... | ..... | ..... |
| 6580 | ..... | ..... | 10.35 | ..... | 1.90 | ..... | 4.04 | ..... | 5.94 | ..... | ..... | ..... |
| 6594 | ..... | ..... | 10.35 | ..... | 2.12 | ..... | 3.85 | ..... | 5.97 | ..... | ..... | ..... |
| 6827 | ..... | ..... | 10.20 | ..... | 1.71 | ..... | 4.33 | ..... | 6.04 | ..... | ..... | ..... |
| 6852 | ..... | ..... | 10.00 | ..... | 2.00 | ..... | 4.09 | ..... | 6.09 | ..... | ..... | ..... |
| 6876 | ..... | ..... | 9.60 | ..... | 1.75 | ..... | 4.26 | ..... | 6.01 | ..... | ..... | ..... |
| 6877 | ..... | ..... | 9.40 | ..... | 2.18 | ..... | 3.88 | ..... | 6.06 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | *Bn, Super, T* | *2.00* | ..... | *4.00* | *Bat G, Bl, Bn* | *6.00* | ..... | ..... | ..... |
| 6577 | **5.10** | 10.35 | 15.45 | ..... | ..... | ..... | 3.41 | ..... | 3.41 | ..... | ..... | ..... |
| 6592 | **5.00** | 9.75 | 14.75 | ..... | ..... | ..... | 3.61 | ..... | 3.61 | ..... | ..... | ..... |
| ..... | *7.00* | *9.00* | *16.00* | *Bn, Super, T* | ..... | ..... | *3.00* | *Bat G, Bl Bn* | *3.00* | ..... | ..... | ..... |
| 6579 | ..... | ..... | 7.45 | ..... | ..... | 2.92 | 4.76 | ..... | **7.68** | ..... | ..... | ..... |
| 6640 | ..... | ..... | 7.80 | ..... | ..... | 3.65 | 4.12 | ..... | 7.77 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | *Bn, T, Fs, G* | ..... | *3.00* | *5.00* | *Bl, Bn, Fs, G, T* | *8.00* | ..... | ..... | ..... |
| 6581 | ..... | ..... | 12.00 | ..... | 1.88 | ..... | 2.13 | ..... | 4.01 | ..... | ..... | ..... |
| 6593 | ..... | ..... | 12.60 | ..... | 1.02 | ..... | 2.92 | ..... | 3.94 | ..... | ..... | ..... |
| 6738 | ..... | ..... | 12.60 | ..... | 1.57 | ..... | 2.28 | ..... | 3.85 | ..... | ..... | ..... |
| 6829 | ..... | ..... | 12.55 | ..... | 1.49 | ..... | 2.62 | ..... | 4.11 | ..... | ..... | ..... |
| 7043 | ..... | ..... | 11.90 | ..... | 1.63 | ..... | 2.40 | ..... | 4.03 | ..... | ..... | ..... |
| ..... | ..... | ..... | *12.00* | *Bn, Super, T* | *2.00* | *4.00* | *2.00* | *Bat G, Bl, Bn, Fs* | *4.00* | ..... | ..... | ..... |
| 6583 | ..... | ..... | ..... | ..... | 4.86 | ..... | 9.43 | ..... | **14.29** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *4.00* | ..... | *11.00* | *Bl* | *15.00* | ..... | ..... | ..... |
| 6584 | ..... | ..... | ..... | ..... | 7.50 | 6.93 | 7.43 | ..... | **14.36** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | *7.50* | *7.50* | *Bl* | *15.00* | ..... | ..... | ..... |
| 6621 | 5.16 | 6.34 | 11.50 | ..... | ..... | ..... | 3.06 | ..... | 3.06 | ..... | ..... | ..... |
| ..... | *6.00* | *6.00* | *12.00* | *Bn, Super, T* | ..... | ..... | *3.00* | *Bat G, Bl, Bn* | *3.00* | ..... | ..... | ..... |
| 6622 | 5.73 | 3.72 | 9.45 | ..... | ..... | ..... | 3.34 | ..... | 3.34 | 1.73 | 1.73 | 0.60 |
| ..... | *6.00* | *4.00* | *10.00* | *Bn, Super, T* | ..... | ..... | *3.00* | *Bat G, Bl, Bn* | *3.00* | *1.50* | *1.50* | ..... |
| 6637 | ..... | ..... | 8.75 | ..... | ..... | 2.06 | 4.80 | ..... | 6.86 | ..... | ..... | ..... |
| 6638 | ..... | ..... | 9.10 | ..... | ..... | 2.50 | 4.56 | ..... | 7.06 | ..... | ..... | ..... |
| ..... | ..... | ..... | *9.00* | *Bn, Super, T* | ..... | *2.00* | *5.00* | *Bat G, Bl, Bn* | *7.00* | ..... | ..... | ..... |
| 6813 | ..... | ..... | 9.20 | ..... | ..... | 2.87 | 4.25 | ..... | 7.12 | ..... | ..... | ..... |
| 6828 | ..... | ..... | 9.05 | ..... | ..... | 3.37 | 3.98 | ..... | 7.35 | ..... | ..... | ..... |
| 7003 | ..... | ..... | 9.35 | ..... | ..... | 2.88 | 4.33 | ..... | 7.21 | ..... | ..... | ..... |
| ..... | ..... | ..... | *9.00* | *Bn, Super, T* | ..... | *3.00* | *4.00* | *Bat G, Bl, Bn, Fs* | *7.00* | ..... | ..... | ..... |
| 6843 | ..... | ..... | 7.90 | ..... | ..... | 3.78 | 4.17 | ..... | 7.95 | ..... | ..... | ..... |
| 7004 | ..... | ..... | 8.35 | ..... | 0.62 | 3.58 | 4.17 | ..... | 8.37 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | *Bn, Fs, G, T* | ..... | *4.00* | *4.00* | *Bl, Bn, Fs, G, T* | *8.00* | ..... | ..... | ..... |
| 6851 | ..... | ..... | 8.30 | ..... | 2.86 | ..... | 4.55 | ..... | **7.41** | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | *Bn, Super, T* | *4.00* | ..... | *4.00* | *Bat G, Bl, Bn* | *8.00* | ..... | ..... | ..... |
| 7005 | ..... | ..... | 12.05 | ..... | 1.82 | ..... | 2.94 | ..... | 4.76 | ..... | ..... | ..... |
| ..... | ..... | ..... | *12.00* | *Bn, Super, T* | *2.00* | ..... | *3.00* | *Bat G, Bl, Bn, Fs* | *5.00* | ..... | ..... | ..... |

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Agricultural Chemical Works (*Continued*). Los Angeles, Cal.** | | |
| 6591* | Tankage | J. M. Webster, Upland | 34.17 |
| 6641* | Tankage | W. H. Collins, Covina | 34.64 |
| | *Guaranteed* | | *32.99* |
| 6864* | Tankage | G. A. Herdeg, Riverside | 34.66 |
| | *Guaranteed* | | *36.00* |
| 6578 | Tankage Fertilizer | E. A. Moore, Redlands | 38.08 |
| | *Guaranteed* | | *38.40* |
| | **American Agricultural Chemical Co., Los Angeles, Cal.** | | |
| 7024* | Bradley's | Pacific Wood & Coal Co., San Diego | 27.20 |
| | *Guaranteed* | | *26.68* |
| 6645 | Bradley's Calif. Vegetable | F. E. Dudderar, Covina | 25.82 |
| 6665 | Bradley's Calif. Vegetable | Pacific Wood & Coal Co., San Diego | 25.94 |
| 7025 | Bradley's Calif. Vegetable | Pacific Wood & Coal Co., San Diego | 25.96 |
| | *Guaranteed* | | *25.12* |
| 6575 | Bradley's Lawn | E. M. Cope Commercial Co., Redlands | 27.50 |
| 6573 | Bradley's Lawn | G. L. Wintherbotham, Riverside | 26.57 |
| 6666 | Bradley's Lawn | Pacific Wood & Coal Co., San Diego | 26.25 |
| 7023 | Bradley's Lawn | Pacific Wood & Coal Co., San Diego | 27.58 |
| | *Guaranteed* | | *26.68* |
| 6663 | Bradley's Lemon Tree | Pacific Wood & Coal Co., San Diego | 26.93 |
| 7002 | Bradley's Lemon Tree | Pacific Wood & Coal Co., San Diego | 27.18 |
| 7032 | Bradley's Lemon Tree | San Diego Land Corp., National City | 27.73 |
| | *Guaranteed* | | *26.68* |
| 6572 | Bradley's Nursery Stock | G. L. Winterbotham, Riverside | 27.32 |
| 6596 | Bradley's Nursery Stock | San Fernando Lemon Assn., San Fernando | 25.58 |
| 6671 | Bradley's Nursery Stock | M. R. Williams, Monrovia | 26.51 |
| 6707 | Bradley's Nursery Stock | E. C. Robinson, Pomona | 26.57 |
| 6770 | Bradley's Nursery Stock | Santa Paula Citrus Fruit Assn., Santa Paula | 26.32 |
| 6899 | Bradley's Nursery Stock | A. W. Jeffrey, Azusa | 27.13 |
| 6915 | Bradley's Nursery Stock | Mrs. J. M. Riley, Los Angeles | 26.70 |
| 6941 | Bradley's Nursery Stock | R. T. Nelson, Upland | 27.29 |
| | *Guaranteed* | | *26.68* |
| 6574 | Bradley's Orange and Lemon | E. M. Cope Commercial Co., Redlands | 27.22 |
| 6664 | Bradley's Orange and Lemon | Pacific Wood & Coal Co., San Diego | 25.40 |
| 7026 | Bradley's Orange and Lemon | Pacific Wood & Coal Co., San Diego | 25.52 |
| | *Guaranteed* | | *25.64* |
| 7027* | ——— | Pacific Wood & Coal Co., San Diego | |
| 6918 | Sulfate of Ammonia | F. E. Dudderar, Covina | |
| | Sold on unit basis. | | |

*6591—81% fine.

*6641—85% fine.

*6864—91% fine.

*7024—No brand name. In violation of California Fertilizer Act.

*7027—No brand name, no statement of derivation. In violation of California Fertilizer Act.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | |
| 6591 | ..... | ..... | 14.05 | ..... | ..... | ..... | 5.53 | ..... | 5.53 | ..... | ..... | ..... |
| 6641 | ..... | ..... | 13.60 | ..... | ..... | ..... | 5.71 | ..... | 5.71 | ..... | ..... | ..... |
| ..... | ..... | ..... | *13.50* | ..... | ..... | ..... | *5.35* | ..... | *5.35* | ..... | ..... | ..... |
| 6864 | ..... | ..... | 19.60 | ..... | ..... | ..... | 4.76 | ..... | 4.76 | ..... | ..... | ..... |
| ..... | ..... | ..... | *20.00* | ..... | ..... | ..... | *5.00* | ..... | *5.00* | ..... | ..... | ..... |
| 6578 | ..... | ..... | 8.95 | ..... | 1.04 | 1.81 | 4.77 | ..... | **7.62** | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | *T* | ..... | *4.00* | *4.00* | *Bl, Bu* | *8.00* | ..... | ..... | ..... |
| 7024 | 8.76 | 1.34 | 10.10 | ..... | 2.06 | 0.86 | 1.20 | ..... | 4.12 | 1.75 | 1.75 | ..... |
| ..... | *9.00* | *1.00* | *10.00* | *Bn, Super* | *2.35* | *0.75* | *1.00* | *Bat G, Bl, Bn, T* | *4.10* | *1.50* | *1.50* | ..... |
| 6645 | 7.75 | 1.30 | 9.05 | ..... | 1.96 | 0.58 | 0.89 | ..... | 3.43 | 4.11 | 4.11 | ..... |
| 6665 | 7.92 | 0.88 | 8.80 | ..... | 2.10 | 0.71 | 0.78 | ..... | 3.59 | 3.91 | 3.91 | ..... |
| 7025 | 8.49 | 0.76 | 9.25 | ..... | 1.95 | 0.77 | 0.72 | ..... | 3.44 | 4.13 | 4.13 | ..... |
| ..... | *8.00* | *1.00* | *9.00* | *Bn, Super* | *1.90* | *0.60* | *0.80* | *Bat G, Bl, Bn, T* | *3.30* | *4.00* | *4.00* | ..... |
| 6575 | 8.85 | 1.40 | 10.25 | ..... | 2.80 | 0.88 | 0.60 | ..... | 4.28 | 1.65 | 1.65 | 0.85 |
| 6573 | 8.40 | 1.60 | 10.00 | ..... | 2.48 | 1.03 | 0.56 | ..... | 4.07 | 1.77 | 1.77 | ..... |
| 6666 | 9.85 | 0.10 | 9.95 | ..... | 2.40 | 0.92 | 0.68 | ..... | 4.00 | 1.69 | 1.69 | ..... |
| 7023 | 8.99 | 1.36 | 10.35 | ..... | 2.46 | 0.86 | 0.88 | ..... | 4.20 | 1.78 | 1.78 | ..... |
| ..... | *9.00* | *1.00* | *10.00* | *Bn, Super* | *2.35* | *0.75* | *1.00* | *Bat G, Bl, Bn, T* | *4.10* | *1.50* | *1.50* | ..... |
| 6663 | 8.16 | 2.34 | 10.50 | ..... | 2.31 | 0.84 | 0.88 | ..... | 4.03 | 1.64 | 1.64 | ..... |
| 7002 | 8.90 | 1.40 | 10.30 | ..... | 2.35 | 0.69 | 1.01 | ..... | 4.05 | 1.91 | 1.91 | ..... |
| 7032 | 9.37 | 1.08 | 10.45 | ..... | 2.52 | 0.96 | 0.71 | ..... | 4.19 | 1.98 | 1.98 | ..... |
| ..... | *9.00* | *1.00* | *10.00* | *Bn, Super* | *2.35* | *0.75* | *1.00* | *Bat G, Bl, Bn, T* | *4.10* | *1.50* | *1.50* | ..... |
| 6572 | 8.70 | 1.50 | 10.20 | ..... | 2.59 | 0.85 | 0.77 | ..... | 4.21 | 1.68 | 1.68 | ..... |
| 6596 | 8.57 | 0.98 | 9.55 | ..... | 2.58 | 0.80 | 0.60 | ..... | 3.98 | 1.50 | 1.50 | ..... |
| 6671 | 8.06 | 1.84 | 9.90 | ..... | 2.51 | 0.88 | 0.71 | ..... | 4.10 | 1.59 | 1.59 | ..... |
| 6707 | 8.48 | 1.52 | 10.00 | ..... | 2.38 | 0.80 | 0.88 | ..... | 4.06 | 1.61 | 1.61 | ..... |
| 6770 | 8.65 | 1.00 | 9.65 | ..... | 2.36 | 0.79 | 0.91 | ..... | 4.06 | 1.66 | 1.66 | ..... |
| 6899 | 8.86 | 0.94 | 9.80 | ..... | ..... | 2.75 | 1.35 | ..... | 4.10 | 1.92 | 1.92 | ..... |
| 6915 | 8.34 | 1.06 | 9.40 | ..... | 2.38 | 0.72 | 1.07 | ..... | 4.17 | 1.74 | 1.74 | ..... |
| 6941 | 8.63 | 1.12 | 9.75 | ..... | 2.37 | 0.67 | 1.17 | ..... | 4.21 | 1.81 | 1.81 | ..... |
| ..... | *9.00* | *1.00* | *10.00* | *Bn, Super* | *2.35* | *0.75* | *1.00* | *Bat G, Bl, Bn, T* | *4.10* | *1.50* | *1.50* | ..... |
| 6574 | 7.72 | 2.28 | 10.00 | ..... | 2.37 | 0.67 | 0.73 | ..... | 3.77 | 3.46 | 3.46 | ..... |
| 6664 | 8.22 | 0.68 | 8.90 | ..... | 2.08 | 0.74 | 0.77 | ..... | 3.59 | 3.29 | 3.29 | ..... |
| 7026 | 9.02 | 0.68 | 9.70 | ..... | 1.82 | 0.69 | 0.99 | ..... | 3.50 | 2.90 | 2.90 | ..... |
| ..... | *8.00* | *1.00* | *9.00* | *Bn, Super* | *2.20* | *0.70* | *0.80* | *Bat G, Bl, Bn, T* | *3.70* | *3.00* | *3.00* | ..... |
| 7027 | 18.04 | 0.66 | 18.70 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 6918 | ..... | ..... | ..... | ..... | ..... | 20.52 | ..... | ..... | 20.52 | ..... | ..... | ..... |

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Armour Fertilizer Works, Los Angeles, Cal.** | | |
| 6849 | Armour's 1916 Fall Brand | E. F. Wilson, Upland | 25.21 |
| | *Guaranteed* | | *24.30* |
| 6555 | Blood | Miss R. Brown, et al, Covina | 62.05 |
| | *Guaranteed* | | *60.90* |
| 6604 | Blood | E. F. Wilson, Upland | 63.80 |
| 6784 | Blood | F. M. Chapman, Covina | 64.31 |
| | *Guaranteed* | | *63.94* |
| 6627 | Blood | J. C. Boyd, Rialto | 63.16 |
| 6668 | Blood | E. F. Wilson, Upland | **61.04** |
| | *Guaranteed* | | *62.74* |
| 6658 | Blood | H. P. Greene, San Diego | 62.10 |
| 6338 | Blood | E. M. Hudson, Los Angeles | 62.05 |
| | *Guaranteed* | | *62.79* |
| 6673 | Blood | A. M. Seeley, Covina | 62.28 |
| | *Guaranteed* | | *63.02* |
| 6697 | Blood | R. T. Murrell, Pomona | 63.02 |
| | *Guaranteed* | | *63.30* |
| 6783 | Blood | Mrs. F. M. Chapman, Covina | 64.95 |
| | *Guaranteed* | | *64.40* |
| 6842 | Blood | J. M. Webster, Upland | 63.11 |
| | *Guaranteed* | | *64.17* |
| 6845 | Blood | E. F. Wilson, Upland | 64.81 |
| | *Guaranteed* | | *63.25* |
| 6846 | Blood | E. F. Wilson, Upland | 64.91 |
| | *Guaranteed* | | *63.48* |
| 6847 | Blood | E. F. Wilson, Upland | 64.35 |
| | *Guaranteed* | | *64.86* |
| 6923 | Blood | C. Menefee, Covina | 61.59 |
| | *Guaranteed* | | *62.10* |
| 6983 | Blood | W. L. Wiley, Glendora | 62.61 |
| | *Guaranteed* | | *61.41* |
| 6609* | Bone Meal | E. F. Wilson, Upland | 36.02 |
| 6680* | Bone Meal | A. M. Seeley, Covina | 36.10 |
| | *Guaranteed* | | *37.30* |
| 6615* | Bone Meal | D. P. Stone, Redlands | 38.02 |
| 6652* | Bone Meal | E. O. Rickard, Riverside | 37.92 |
| 6782* | Bone Meal | C. S. Whitcomb, Glendora | 37.93 |
| | *Guaranteed* | | *36.60* |
| 6655* | Bone Meal | E. F. Wilson, Upland | 38.60 |
| 6672* | Bone Meal | E. R. Brubaker, et al, Azusa | 37.93 |
| 6736* | Bone Meal | A. P. Griffith Estate, Azusa | 38.83 |
| | *Guaranteed* | | *39.06* |
| 6662* | Bone Meal | H. P. Greene, San Diego | 31.32 |
| | *Guaranteed* | | *32.20* |
| 6689* | Bone Meal | Louis Steel, Highland | 36.12 |
| | *Guaranteed* | | *35.70* |
| 6692* | Bone Meal | W. T. Henderson, Riverside | 39.33 |
| | *Guaranteed* | | *38.02* |
| 6696* | Bone Meal | R. T. Murrell, Pomona | 36.53 |
| | *Guaranteed* | | *37.20* |

*6782—60% fine. *6662—97% fine. *6680—71% fine.
*6655—61% fine. *6689—74% fine. *6615—63% fine.
*6672—61% fine. *6692—50% fine. *6652—61% fine.
*6736—60% fine. *6609—76% fine. *6696—73% fine.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | Chlorin |
| 6849 | ..... | ..... | 15.25 | ..... | ..... | ..... | 2.20 | ..... | 2.20 | 1.80 | 1.80 | 0.80 |
| ..... | ..... | ..... | *15.00* | *Bn* | ..... | ..... | *2.00* | *Bn, T* | *2.00* | *2.00* | *2.00* | ..... |
| 6555 | ..... | ..... | ..... | ..... | ..... | ..... | 13.49 | ..... | 13.49 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.24* | ..... | *13.24* | ..... | ..... | ..... |
| 6604 | ..... | ..... | ..... | ..... | ..... | ..... | 13.87 | ..... | 13.87 | ..... | ..... | ..... |
| 6784 | ..... | ..... | ..... | ..... | ..... | ..... | 13.98 | ..... | 13.98 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.90* | ..... | *13.90* | ..... | ..... | ..... |
| 6627 | ..... | ..... | ..... | ..... | ..... | ..... | 13.73 | ..... | 13.73 | ..... | ..... | ..... |
| 6668 | ..... | ..... | ..... | ..... | ..... | ..... | 13.27 | ..... | **13.27** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.64* | ..... | *13.64* | ..... | ..... | ..... |
| 6658 | ..... | ..... | ..... | ..... | ..... | ..... | 13.50 | ..... | 13.50 | ..... | ..... | ..... |
| 6338 | ..... | ..... | ..... | ..... | ..... | ..... | 13.49 | ..... | 13.49 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.65* | ..... | *13.65* | ..... | ..... | ..... |
| 6673 | ..... | ..... | ..... | ..... | ..... | ..... | 13.54 | ..... | 13.54 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.70* | ..... | *13.70* | ..... | ..... | ..... |
| 6697 | ..... | ..... | ..... | ..... | ..... | ..... | 13.70 | ..... | 13.70 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.76* | ..... | *13.76* | ..... | ..... | ..... |
| 6783 | ..... | ..... | ..... | ..... | ..... | ..... | 14.12 | ..... | 14.12 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *14.00* | ..... | *14.00* | ..... | ..... | ..... |
| 6842 | ..... | ..... | ..... | ..... | ..... | ..... | 13.72 | ..... | 13.72 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.95* | ..... | *13.95* | ..... | ..... | ..... |
| 6945 | ..... | ..... | ..... | ..... | ..... | ..... | 14.09 | ..... | 14.09 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.75* | ..... | *13.75* | ..... | ..... | ..... |
| 6846 | ..... | ..... | ..... | ..... | ..... | ..... | 14.11 | ..... | 14.11 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.80* | ..... | *13.80* | ..... | ..... | ..... |
| 6847 | ..... | ..... | ..... | ..... | ..... | ..... | 13.99 | ..... | 13.99 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *14.10* | ..... | *14.10* | ..... | ..... | ..... |
| 6923 | ..... | ..... | ..... | ..... | ..... | ..... | 13.39 | ..... | 13.39 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.50* | ..... | *13.50* | ..... | ..... | ..... |
| 6983 | ..... | ..... | ..... | ..... | ..... | ..... | 13.61 | ..... | 13.61 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.35* | ..... | *13.35* | ..... | ..... | ..... |
| 6609 | ..... | ..... | 27.60 | ..... | ..... | ..... | 2.54 | ..... | 2.54 | ..... | ..... | ..... |
| 6680 | ..... | ..... | 27.50 | ..... | ..... | ..... | 2.58 | ..... | 2.58 | ..... | ..... | ..... |
| ..... | ..... | ..... | *24.00* | ..... | ..... | ..... | *2.75* | ..... | *2.75* | ..... | ..... | ..... |
| 6615 | ..... | ..... | 26.60 | ..... | ..... | ..... | 3.20 | ..... | 3.20 | ..... | ..... | ..... |
| 6652 | ..... | ..... | 26.00 | ..... | ..... | ..... | 3.30 | ..... | 3.30 | ..... | ..... | ..... |
| 6782 | ..... | ..... | 26.40 | ..... | ..... | ..... | 3.22 | ..... | 3.22 | ..... | ..... | ..... |
| ..... | ..... | ..... | *26.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 6655 | ..... | ..... | 27.00 | ..... | ..... | ..... | 3.25 | ..... | 3.25 | ..... | ..... | ..... |
| 6672 | ..... | ..... | **26.30** | ..... | ..... | ..... | 3.24 | ..... | 3.24 | ..... | ..... | ..... |
| 6736 | ..... | ..... | 27.40 | ..... | ..... | ..... | 3.22 | ..... | 3.22 | ..... | ..... | ..... |
| ..... | ..... | ..... | *27.75* | ..... | ..... | ..... | *3.20* | ..... | *3.20* | ..... | ..... | ..... |
| 6662 | ..... | ..... | **23.60** | ..... | ..... | ..... | 2.29 | ..... | 2.29 | ..... | ..... | ..... |
| ..... | ..... | ..... | *26.00* | ..... | ..... | ..... | *2.00* | ..... | *2.00* | ..... | ..... | ..... |
| 6689 | ..... | ..... | 26.30 | ..... | ..... | ..... | 2.83 | ..... | 2.83 | ..... | ..... | ..... |
| ..... | ..... | ..... | *25.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 6692 | ..... | ..... | 23.80 | ..... | ..... | ..... | 4.07 | ..... | 4.07 | ..... | ..... | ..... |
| ..... | ..... | ..... | *23.23* | ..... | ..... | ..... | *3.89* | ..... | *3.89* | ..... | ..... | ..... |
| 6696 | ..... | ..... | 27.00 | ..... | ..... | ..... | 2.78 | ..... | 2.78 | ..... | ..... | ..... |
| ..... | ..... | ..... | *27.06* | ..... | ..... | ..... | *2.92* | ..... | *2.92* | ..... | ..... | ..... |

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Armour Fertilizer Works** (*Continued*). **Los Angeles, Cal.** | | |
| 6699* | Bone Meal | Azusa Foot-Hill Citrus Co., Azusa | 36.27 |
| 6700* | Bone Meal | Azusa Foot-Hill Citrus Co., Azusa | 37.04 |
| 6701* | Bone Meal | Azusa Foot-Hill Citrus Co., Azusa | 36.97 |
| 6702* | Bone Meal | Azusa Foot-Hill Citrus Co., Azusa | 34.61 |
| | *Guaranteed* | | *32.60* |
| 6712* | Bone Meal | Azusa Foot-Hill Citrus Co., Azusa | 36.36 |
| | *Guaranteed* | | *35.93* |
| 6713* | Bone Meal | Azusa Foot-Hill Citrus Co., Azusa | 33.14 |
| 6714* | Bone Meal | Azusa Foot-Hill Citrus Co., Azusa | 33.10 |
| 6715* | Bone Meal | Azusa Foot-Hill Citrus Co., Azusa | 32.81 |
| 6719* | Bone Meal | Azusa Foot-Hill Citrus Co., Azusa | 33.20 |
| 6720* | Bone Meal | Azusa Foot-Hill Citrus Co., Azusa | 32.38 |
| | *Guaranteed* | | *30.80* |
| 6721* | Bone Meal | Mrs. James Fleming, San Bernardino | 39.27 |
| | *Guaranteed* | | *38.38* |
| 6788* | Bone Meal | W. H. Lindley, Ontario | 36.88 |
| | *Guaranteed* | | *36.85* |
| 6837* | Bone Meal | E. M. Hudson, Los Angeles | 33.59 |
| | *Guaranteed* | | *33.72* |
| 7031* | Bone Meal | H. P. Greene, San Diego | 37.60 |
| | *Guaranteed* | | *35.10* |
| 6610 | Cropmaker Special | E. F. Wilson, Upland | 29.54 |
| 6616 | Cropmaker Special | R. E. Fairchild, Redlands | 29.07 |
| 6674 | Cropmaker Special | A. M. Seeley, Covina | 28.46 |
| 6688 | Cropmaker Special | Louis Steel, Highland | 28.21 |
| 6691 | Cropmaker Special | W. T. Henderson, Riverside | 28.54 |
| 6694 | Cropmaker Special | W. T. Henderson, Riverside | 28.77 |
| 6695 | Cropmaker Special | R. T. Murrell, Pomona | 27.58 |
| 6722 | Cropmaker Special | L. S. Steele, Highland | 27.11 |
| 6836 | Cropmaker Special | E. M. Hudson, Los Angeles | 28.29 |
| 7038 | Cropmaker Special | Mrs. M. H. La Fetra, Glendora | 29.93 |
| | *Guaranteed* | | *27.70* |
| 6661 | Cropmaker Special | H. P. Greene, San Diego | 27.42 |
| | *Guaranteed* | | *27.10* |
| 6839* | Fish Meal | E. M. Hudson, Los Angeles | 46.17 |
| | *Guaranteed* | | *46.55* |
| 6840* | Fish Meal | E. M. Hudson, Los Angeles | 34.41 |
| | *Guaranteed* | | *34.30* |
| 6558 | Guano | Alta Cresta Rancho Riverside | **23.49** |
| | *Guaranteed* | | *25.97* |
| 6660 | Lawn Special | H. P. Greene, San Diego | **27.44** |
| 6693 | Lawn Special | W. T. Henderson, Riverside | 27.46 |
| 6742 | Lawn Special | Garden Grove Lumber and Cement Co., Garden Grove | 26.00 |
| 6835 | Lawn Special | E. M. Hudson, Los Angeles | 26.85 |
| | *Guaranteed* | | *25.70* |
| 6626 | Nitrate of Soda | J. C. Boyd, Rialto | 58.56 |
| 6656 | Nitrate of Soda | E. F. Wilson, Upland | 59.85 |
| 6659 | Nitrate of Soda | H. P. Greene, San Diego | 59.09 |

*6699—73% fine. *6702—74% fine. *6714—57% fine.
*6700—70% fine. *6712—73% fine. *6715—55% fine.
*6701—71% fine. *6713—55% fine. *6719—60% fine.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | |
| 6699 | ..... | ..... | 27.10 | ..... | ..... | ..... | 2.70 | ..... | 2.70 | ..... | ..... | ..... |
| 6700 | ..... | ..... | 26.10 | ..... | ..... | ..... | 3.08 | ..... | 3.08 | ..... | ..... | ..... |
| 6701 | ..... | ..... | 24.70 | ..... | ..... | ..... | 3.35 | ..... | 3.35 | ..... | ..... | ..... |
| 6702 | ..... | ..... | 25.40 | ..... | ..... | ..... | 2.67 | ..... | 2.67 | ..... | ..... | ..... |
| ..... | ..... | ..... | *24.00* | ..... | ..... | ..... | *2.50* | ..... | *2.50* | ..... | ..... | ..... |
| 6712 | ..... | ..... | 27.30 | ..... | ..... | ..... | 2.68 | ..... | 2.68 | ..... | ..... | ..... |
| ..... | ..... | ..... | *27.70* | ..... | ..... | ..... | *2.50* | ..... | *2.50* | ..... | ..... | ..... |
| 6713 | ..... | ..... | 22.40 | ..... | ..... | ..... | 2.95 | ..... | 2.95 | ..... | ..... | ..... |
| 6714 | ..... | ..... | 22.40 | ..... | ..... | ..... | 2.94 | ..... | 2.94 | ..... | ..... | ..... |
| 6715 | ..... | ..... | 23.40 | ..... | ..... | ..... | 2.67 | ..... | 2.67 | ..... | ..... | ..... |
| 6719 | ..... | ..... | 23.20 | ..... | ..... | ..... | 2.80 | ..... | 2.80 | ..... | ..... | ..... |
| 6720 | ..... | ..... | 21.70 | ..... | ..... | ..... | 2.92 | ..... | 2.92 | ..... | ..... | ..... |
| ..... | ..... | ..... | *22.00* | ..... | ..... | ..... | *2.50* | ..... | *2.50* | ..... | ..... | ..... |
| 6721 | ..... | ..... | 27.50 | ..... | ..... | ..... | 3.30 | ..... | 3.30 | ..... | ..... | ..... |
| ..... | ..... | ..... | *27.00* | ..... | ..... | ..... | *3.20* | ..... | *3.20* | ..... | ..... | ..... |
| 6788 | ..... | ..... | 26.80 | ..... | ..... | ..... | 2.90 | ..... | 2.90 | ..... | ..... | ..... |
| ..... | ..... | ..... | *27.25* | ..... | ..... | ..... | *2.80* | ..... | *2.80* | ..... | ..... | ..... |
| 6737 | ..... | ..... | 18.50 | ..... | ..... | ..... | 3.85 | ..... | 3.85 | ..... | ..... | ..... |
| ..... | ..... | ..... | *18.40* | ..... | ..... | ..... | *3.90* | ..... | *3.90* | ..... | ..... | ..... |
| 7031 | ..... | ..... | 21.10 | ..... | ..... | ..... | 4.23 | ..... | 4.23 | ..... | ..... | ..... |
| ..... | ..... | ..... | *21.15* | ..... | ..... | ..... | *3.65* | ..... | *3.65* | ..... | ..... | ..... |
| 6610 | **6.62** | 3.48 | 10.10 | ..... | 1.81 | ..... | 2.48 | ..... | 4.29 | 2.66 | 2.66 | 0.80 |
| 6616 | **6.81** | 3.64 | 10.45 | ..... | 1.76 | ..... | 2.38 | ..... | 4.14 | 2.50 | 2.50 | 0.97 |
| 6674 | **3.42** | 6.28 | 9.70 | ..... | 0.31 | ..... | 3.73 | ..... | 4.04 | ..... | 2.14 | 1.05 |
| 6688 | **3.56** | 5.74 | 9.30 | ..... | 0.37 | ..... | 3.78 | ..... | 4.15 | 1.80 | 1.80 | 0.97 |
| 6691 | 7.50 | 3.10 | 10.60 | ..... | 1.49 | ..... | 2.46 | ..... | 3.95 | 2.51 | 2.51 | 0.67 |
| 6694 | 7.24 | 3.36 | 10.60 | ..... | 1.39 | ..... | 2.62 | ..... | 4.01 | ..... | 2.42 | 1.00 |
| 6695 | **3.57** | 6.38 | 9.95 | ..... | ..... | ..... | 3.83 | ..... | 3.83 | ..... | 1.77 | 1.00 |
| 6722 | **6.57** | 3.78 | 10.35 | ..... | 1.54 | ..... | 2.23 | ..... | 3.77 | ..... | 2.13 | 1.25 |
| 6836 | **5.36** | 4.04 | 10.40 | ..... | 1.60 | ..... | 2.39 | ..... | 3.99 | ..... | 2.33 | 1.35 |
| 7038 | 7.53 | 3.32 | 10.85 | ..... | 2.47 | ..... | 1.96 | ..... | 4.43 | 2.15 | 2.15 | 0.95 |
| ..... | *8.00* | *2.00* | *10.00* | *Bn, Super, G* | *1.50* | ..... | *2.50* | *Bl, Bn, G, T* | *4.00* | *2.00* | *2.00* | ..... |
| 6661 | **6.96** | 3.44 | 10.40 | ..... | 2.16 | ..... | 1.64 | ..... | 3.80 | 2.64 | 2.64 | 0.75 |
| ..... | *8.00* | *2.00* | *10.00* | *Bn, G* | *2.50* | ..... | *1.50* | *Bl, Bn, G, T, CSM* | *4.00* | *2.00* | *2.00* | ..... |
| 6839 | ..... | ..... | 8.70 | ..... | ..... | ..... | 9.11 | ..... | 9.11 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.35* | ..... | ..... | ..... | *9.25* | ..... | *9.25* | ..... | ..... | ..... |
| 6840 | ..... | ..... | 4.65 | ..... | ..... | ..... | 7.08 | ..... | 7.08 | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.00* | ..... | ..... | ..... | *7.00* | ..... | *7.00* | ..... | ..... | ..... |
| 6558 | ..... | ..... | 6.10 | ..... | 1.35 | 0.35 | 2.76 | ..... | **4.46** | ..... | 0.62 | ..... |
| ..... | ..... | ..... | *5.90* | ..... | ..... | ..... | *4.86* | ..... | *4.86* | ..... | *0.46* | ..... |
| 6660 | 4.45 | 1.10 | 5.55 | ..... | 0.95 | ..... | 3.74 | ..... | 4.69 | 2.38 | 2.38 | 0.95 |
| 6693 | 3.95 | 1.80 | 5.75 | ..... | 1.31 | ..... | 3.45 | ..... | 4.76 | ..... | 2.13 | 1.72 |
| 6742 | 3.83 | 1.22 | 5.05 | ..... | 0.94 | ..... | 3.62 | ..... | 4.56 | 1.95 | 1.95 | 0.70 |
| 6835 | 3.57 | 1.98 | 5.55 | ..... | 1.52 | ..... | 3.20 | ..... | 4.72 | ..... | 2.00 | 1.60 |
| ..... | *4.00* | *1.00* | *5.00* | *Bn, Super, G* | *1.00* | ..... | *3.50* | *Bl, Bn, G, T* | *4.50* | *2.00* | *2.00* | ..... |
| 6626 | ..... | ..... | ..... | ..... | 15.41 | ..... | ..... | ..... | 15.41 | ..... | ..... | ..... |
| 6656 | ..... | ..... | ..... | ..... | 15.75 | ..... | ..... | ..... | 15.75 | ..... | ..... | ..... |
| 6659 | ..... | ..... | ..... | ..... | 15.55 | ..... | ..... | ..... | 15.55 | ..... | ..... | ..... |

*6720—65% fine.
*6721—54% fine.
*6788—68% fine.
*6837—25% fine.
*7031—16% fine.
*6839—71% fine.
*6840—68% fine.

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Armour Fertilizer Works** (*Continued*). **Los Angeles, Cal.** | | |
| 6676 | Nitrate of Soda | A. M. Seeley, Covina | 58.33 |
| 6767 | Nitrate of Soda | Fillmore Citrus Fruit Assn., Fillmore | 57.38 |
| 6833 | Nitrate of Soda | E. M. Hudson, Los Angeles | 59.20 |
| 6953 | Nitrate of Soda | J. A. Mack, Bloomington | 58.79 |
| | *Guaranteed* | | *57.00* |
| 6608 | Special | E. F. Wilson, Upland | 33.46 |
| | *Guaranteed* | | *31.80* |
| 6706 | Special | Mrs. S. F. McDonald, Glendora | 31.45 |
| | *Guaranteed* | | *29.80* |
| 6740 | Special | Garden Grove Lumber & Cement Co., Garden Grove | 23.73 |
| | *Guaranteed* | | *24.00* |
| 6872 | Special | Mrs. James Fleming, San Bernardino | 27.53 |
| | *Guaranteed* | | *26.70* |
| 6834 | Special | E. M. Hudson, Los Angeles | 22.15 |
| | *Guaranteed* | | *22.20* |
| 6988 | Special | Aggeler & Musser Seed Co., Los Angeles | 21.70 |
| 7030 | Special | H. P. Greene, San Diego | 21.08 |
| | *Guaranteed* | | *21.30* |
| 6741 | Special Potato | Garden Grove Lumber & Cement Co., Garden Grove | 22.64 |
| | *Guaranteed* | | *22.40* |
| 7028 | Special 4–10–1 | H. P. Greene, San Diego | 25.65 |
| | *Guaranteed* | | *25.80* |
| 6675 | Special 6–8–1 | A. M. Seeley, Covina | 34.50 |
| 6703 | Special 6–8–1 | Jacob Maechtlen, Covina | 35.20 |
| | *Guaranteed* | | *34.60* |
| 6984 | Special 6–8–1 | Mrs. S. F. McDonald, Glendora | 32.35 |
| 6985 | Special 6–8–1 | Jacob Maechtlen, Covina | 31.43 |
| | *Guaranteed* | | *32.80* |
| 7029 | Superphosphate | H. P. Greene, San Diego | 15.96 |
| | *Guaranteed* | | *16.69* |
| 6562* | Tankage | Judge Chas. Silent, Glendora | 45.30 |
| | *Guaranteed* | | *46.15* |
| 6605* | Tankage | E. F. Wilson, Upland | 43.03 |
| 6657* | Tankage | E. F. Wilson, Upland | 41.07 |
| | *Guaranteed* | | *40.80* |
| 6606* | Tankage | E. F. Wilson, Upland | **36.24** |
| | *Guaranteed* | | *43.75* |
| 6607* | Tankage | E. F. Wilson, Upland | 42.15 |
| | *Guaranteed* | | *41.88* |
| 6667* | Tankage | E. F. Wilson, Upland | 41.34 |
| | *Guaranteed* | | *41.91* |
| 6698* | Tankage | J. J. Baynham, Claremont | 40.41 |
| | *Guaranteed* | | *40.43* |
| 6759* | Tankage | W. T. Henderson, Riverside | 38.54 |
| | *Guaranteed* | | *38.80* |

*6562—86% fine. *6657—65% fine.
*6605—65% fine. *6606—62% fine.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | Chlorin |
| 6676 | ..... | ..... | ..... | ..... | 15.35 | ..... | ..... | ..... | 15.35 | ..... | ..... | ..... |
| 6767 | ..... | ..... | ..... | ..... | 15.10 | ..... | ..... | ..... | 15.10 | ..... | ..... | ..... |
| 6833 | ..... | ..... | ..... | ..... | 15.58 | ..... | ..... | ..... | 15.58 | ..... | ..... | ..... |
| 6833 | ..... | ..... | ..... | ..... | 15.47 | ..... | ..... | ..... | 15.47 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... |
| 6608 | ..... | ..... | 10.40 | ..... | 1.19 | 0.96 | 3.04 | ..... | 5.19 | 2.55 | 2.55 | ..... |
| ..... | ..... | ..... | *10.00* | *Bn, Super, G* | *1.00* | *1.00* | *3.00* | *Bl, Bn, G, T* | *5.00* | *2.00* | *2.00* | ..... |
| 6706 | 19.12 | 1.38 | 20.50 | ..... | ..... | ..... | 2.25 | ..... | 2.25 | 3.10 | 3.10 | ..... |
| ..... | ..... | ..... | *20.00* | *Bn, Super* | ..... | ..... | *2.00* | *Bn* | *2.00* | *3.00* | *3.00* | ..... |
| 6740 | 3.58 | 2.72 | 6.30 | ..... | ..... | ..... | 3.84 | ..... | 3.84 | 1.16 | 1.16 | 0.85 |
| ..... | *4.00* | *2.00* | *6.00* | *Bn, Super, G* | ..... | ..... | *4.00* | *Bl, Bn, G, T, CSM* | *4.00* | *1.00* | *1.00* | ..... |
| 6872 | **5.92** | 4.98 | 10.90 | ..... | 1.57 | ..... | 2.40 | ..... | 3.97 | 1.19 | 1.19 | 0.67 |
| ..... | *8.00* | *2.00* | *10.00* | *Bn, Super, G* | *1.50* | ..... | *2.50* | *Bl, Bn, G, T* | *4.00* | *1.00* | *1.00* | ..... |
| 6834 | **3.80** | 5.90 | 9.70 | ..... | ..... | ..... | 3.05 | ..... | 3.05 | 0.75 | 0.75 | 0.80 |
| ..... | *5.00* | *5.00* | *10.00* | *Bn, Super, G* | ..... | ..... | *3.00* | *Bl, Bn, G, T* | *3.00* | *0.50* | *0.50* | ..... |
| 6988 | 6.84 | 3.66 | 10.50 | ..... | 1.37 | ..... | 1.60 | ..... | 2.97 | 0.65 | 0.65 | 0.75 |
| 7030 | **6.38** | 4.22 | 10.60 | ..... | 1.59 | ..... | 1.25 | ..... | 2.84 | 0.68 | 0.68 | 0.85 |
| ..... | *7.50* | *2.50* | *10.00* | *Bn, Super, G* | . | ..... | *1.50* | *Bl, Bn, G, T* | *3.00* | *0.50* | *0.50* | ..... |
| 6741 | **4.94** | 2.96 | 7.90 | ..... | ..... | ..... | 3.13 | ..... | 3.13 | 1.76 | 1.76 | 0.85 |
| ..... | *6.00* | *2.00* | *8.00* | *Bn, Super, G* | ..... | ..... | *3.00* | *Bl, Bn, G, T, CSM* | *3.00* | *2.00* | *2.00* | ..... |
| 7028 | **6.40** | 4.20 | 10.60 | ..... | 1.23 | 1.54 | 1.06 | ..... | 3.83 | 0.92 | 0.92 | ..... |
| ..... | *7.50* | *2.50* | *10.00* | *Bn, Super, G* | *1.50* | *1.50* | *1.00* | *Bl, Bn, G, T* | *4.00* | *1.00* | *1.00* | ..... |
| 6675 | ..... | ..... | 7.75 | ..... | ..... | ..... | 5.99 | ..... | 5.99 | ..... | 1.17 | 1.45 |
| 6703 | ..... | ..... | 8.15 | ..... | ..... | ..... | 6.08 | ..... | 6.08 | ..... | 1.11 | 1.57 |
| ..... | ..... | ..... | *8.00* | *Bn, G, CSM* | ..... | ..... | *6.00* | *Bl, Bn, G T, CSM* | *6.00* | *1.00* | *1.00* | ..... |
| 6984 | 3.63 | 4.02 | 7.65 | ..... | 1.82 | 1.12 | 2.99 | ..... | 5.93 | 1.14 | 1.14 | 0.80 |
| 6985 | **2.83** | 5.32 | 8.15 | ..... | 1.41 | 1.06 | 3.08 | ..... | **5.55** | 1.16 | 1.16 | 0.80 |
| ..... | *4.00* | *4.00* | *8.00* | *Bn, G, Super* | *2.00* | *100* | *3.00* | *Bl, Bn, G, T* | *6.00* | *1.00* | *1.00* | ..... |
| 7029 | 16.98 | 0.72 | 17.70 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *17.75* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 6562 | ..... | ..... | 6.20 | ..... | ..... | ..... | 9.31 | ..... | 9.31 | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.90* | ..... | ..... | ..... | *9.55* | ..... | *9.55* | ..... | ..... | ..... |
| 6605 | ..... | ..... | 9.30 | ..... | ..... | ..... | 8.30 | ..... | 8.30 | ..... | ..... | ..... |
| 6657 | ..... | ..... | 8.45 | ..... | ..... | ..... | 7.99 | ..... | 7.99 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *8.00* | ..... | *8.00* | ..... | ..... | ..... |
| 6606 | ..... | ..... | **5.95** | ..... | ..... | ..... | 7.29 | ..... | **7.29** | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *8.67* | ..... | *8.67* | ..... | ..... | ..... |
| 6607 | ..... | ..... | 9.80 | ..... | ..... | ..... | 8.02 | ..... | 8.02 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.67* | ..... | ..... | ..... | *7.82* | ..... | *7.82* | ..... | ..... | ..... |
| 6667 | ..... | ..... | 11.85 | ..... | ..... | ..... | 7.51 | ..... | 7.51 | ..... | ..... | ..... |
| ..... | ..... | ..... | *12.10* | ..... | ..... | ..... | *7.60* | ..... | *7.60* | ..... | ..... | ..... |
| 6698 | ..... | ..... | 6.50 | ..... | ..... | ..... | 8.15 | ..... | 8.15 | ..... | ..... | ..... |
| ..... | ..... | ..... | *6.02* | ..... | ..... | ..... | *8.23* | ..... | *8.23* | ..... | ..... | ..... |
| 6759 | ..... | ..... | **15.20** | ..... | ..... | ..... | 6.34 | ..... | 6.34 | ..... | ..... | ..... |
| ..... | ..... | ..... | *17.09* | ..... | ..... | ..... | *6.10* | ..... | *6.10* | ..... | ..... | ..... |

*6607—78% fine.
*6667—77% fine.
*6698—71% fine.
*6759—81% fine.

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Armour Fertilizer Works** (*Continued*). **Los Angeles, Cal.** | | |
| 6760* | Tankage | W. T. Henderson, Riverside | 41.61 |
| | *Guaranteed* | | *44.77* |
| 6761* | Tankage | W. T. Henderson, Riverside | 41.91 |
| | *Guaranteed* | | *39.75* |
| 6768* | Tankage | Fillmore Citrus Fruit Assn., Fillmore | 41.80 |
| | *Guaranteed* | | *42.12* |
| 6787* | Tankage | Grant Chapman et al., Covina | 43.24 |
| 6848* | Tankage | John G. Gaylord, Ontario | 42.46 |
| | *Guaranteed* | | *42.73* |
| 6850* | Tankage | E. F. Wilson, Upland | 40.92 |
| | *Guaranteed* | | *40.80* |
| 6904* | Tankage | Dr. E. W. Burke, Redlands | 32.38 |
| | *Guaranteed* | | *31.55* |
| 6952* | Tankage | J. A. Mack, Bloomington | **39.67** |
| | *Guaranteed* | | *41.61* |
| 6954* | Tankage | J. V. Zimmerman, Rialto | 39.71 |
| | *Guaranteed* | | *40.31* |
| 6844* | Tankage | E. L. Mathews, et al, Upland | |
| | Sold on Station Analysis. | | |
| | **Rogers, Brown & Co., Los Angeles, Cal.** | | |
| 6931 | Blood | Monte Vista Assn., Riverside | **52.76** |
| | *Guaranteed* | | *62.56* |
| 6677* | Fish Meal | H. D. Derwin, Upland | **48.96** |
| 6678* | Fish Meal | H. D. Derwin, Upland | **49.35** |
| | *Guaranteed* | | *52.05* |
| 7035* | Fish Meal | Indian Hills Citrus Assn., North Pomona | 52.00 |
| | *Guaranteed* | | *52.32* |
| 7040* | Fish Meal | W. K. Hayes, Los Angeles | **49.55** |
| | *Guaranteed* | | *5168* |
| 6709* | Salmon Meal | David Hewes Realty Co., Orange | 44.23 |
| | *Guaranteed* | | *45.20* |
| 6806* | Tankage | N. B. Hinckley, Bryn Mawr | **44.68** |
| 6883* | Tankage | C. A. Boettger, Redlands | **45.46** |
| | *Guaranteed* | | *47.95* |
| 7000* | Tankage | West Highland Citrus Assn., West Highland | **31.02** |
| | *Guaranteed* | | *33.20* |
| 7033* | Tankage | B. L. King, et al, Covina | 47.45 |
| 7052* | Tankage | Geo. W. Richardson, Glendora | 45.13 |
| | *Guaranteed* | | *45.10* |
| 7055* | Tankage | San Jacinto Packing Co., Arlington | 48.84 |
| | *Guaranteed* | | *47.30* |
| 6944* | Whale Meat and Bone | Santiago Orange Growers' Assn., Orange | **36.56** |
| | *Guaranteed* | | *40.80* |

*6760—75% fine.
*6761—65% fine. Contains hoof.
*6768—67% fine.
*6787—78% fine.
*6848—81% fine.
*6850—59% fine.
*6904—53% fine.
*6952—81% fine.
*6954—68% fine.
*6844—75% fine.
*6677—71% fine.
*6678—72% fine.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | Chlorin |
| 6760 | ..... | ..... | **11.35** | ..... | ..... | ..... | 7.65 | ..... | **7.65** | ..... | ..... | ..... |
| ..... | ..... | ..... | *12.67* | ..... | ..... | ..... | *8.16* | ..... | *8.16* | ..... | ..... | ..... |
| 6761 | ..... | ..... | 7.95 | ..... | ..... | ..... | 8.26 | ..... | 8.26 | ..... | ..... | ..... |
| ..... | ..... | ..... | *6.50* | ..... | ..... | ..... | *8.00* | ..... | *8.00* | ..... | ..... | ..... |
| 6768 | ..... | ..... | 7.60 | ..... | ..... | ..... | 8.29 | ..... | 8.29 | ..... | ..... | ..... |
| ..... | ..... | ..... | *7.87* | ..... | ..... | ..... | *8.32* | ..... | *8.32* | ..... | ..... | ..... |
| 6787 | ..... | ..... | 10.80 | ..... | ..... | ..... | 8.11 | ..... | 8.11 | ..... | ..... | ..... |
| 6948 | ..... | ..... | 11.50 | ..... | ..... | ..... | 7.82 | ..... | 7.82 | ..... | ..... | ..... |
| ..... | ..... | ..... | *11.70* | ..... | ..... | ..... | *7.85* | ..... | *7.85* | ..... | ..... | ..... |
| 6850 | ..... | ..... | 8.55 | ..... | ..... | ..... | 7.94 | ..... | 7.94 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *8.00* | ..... | *8.00* | ..... | ..... | ..... |
| 6904 | ..... | ..... | 13.00 | ..... | ..... | ..... | 5.29 | ..... | 5.29 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.50* | ..... | ..... | ..... | *5.50* | ..... | *5.50* | ..... | ..... | ..... |
| 6952 | ..... | ..... | 11.60 | ..... | ..... | ..... | 7.17 | ..... | **..17** | ..... | ..... | ..... |
| ..... | ..... | ..... | *12.30* | ..... | ..... | .... | **7.50** | ..... | *7.50* | ..... | ..... | ..... |
| 6954 | ..... | ..... | 5.50 | ..... | ..... | .... | 8.15 | ..... | 8.15 | ..... | ..... | ..... |
| ..... | ..... | ..... | *6.04* | ..... | ..... | ..... | *8.20* | ..... | *8.20* | ..... | ..... | ..... |
| 6844 | ..... | ..... | 12.20 | ..... | ..... | ..... | 7.40 | ..... | 7.40 | ..... | ..... | ..... |
| 6931 | ..... | ..... | ..... | ..... | ..... | ..... | 11.47 | ..... | **11.47** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.60* | ..... | *13.60* | ..... | ..... | ..... |
| 6677 | ..... | ..... | 6.10 | ..... | ..... | ..... | 9.88 | ..... | **9.88** | ..... | ..... | ..... |
| 6678 | ..... | ..... | 5.85 | ..... | ..... | ..... | 10.02 | ..... | **10.02** | ..... | ..... | ..... |
| ..... | ..... | ..... | *6.50* | ..... | ..... | ..... | *10.50* | ..... | *10.50* | ..... | ..... | ..... |
| 7035 | ..... | ..... | 5.40 | ..... | ..... | ..... | 10.96 | ..... | 10.96 | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.60* | ..... | ..... | ..... | *11.00* | ..... | *11.00* | ..... | ..... | ..... |
| 7040 | ..... | ..... | 6.30 | ..... | ..... | ..... | 10.26 | ..... | **10.26** | ..... | ..... | ..... |
| ..... | ..... | ..... | *6.25* | ..... | ..... | ..... | *10.75* | ..... | *10.75* | ..... | ..... | ..... |
| 6709 | ..... | ..... | 8.00 | ..... | ..... | ..... | 8.78 | ..... | 8.78 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *9.00* | ..... | *9.00* | ..... | ..... | ..... |
| 6806 | ..... | ..... | 4.05 | ..... | ..... | ..... | 9.51 | ..... | **9.51** | ..... | ..... | ..... |
| 6883 | ..... | ..... | 4.35 | ..... | ..... | ..... | 9.64 | ..... | **9.64** | ..... | ..... | ..... |
| ..... | ..... | ..... | *4.63* | ..... | ..... | ..... | *10.16* | ..... | *10.16* | ..... | ..... | ..... |
| 7000 | ..... | ..... | 16.60 | ..... | ..... | ..... | 4.41 | ..... | **4.41** | ..... | ..... | ..... |
| ..... | ..... | ..... | *16.00* | ..... | ..... | ..... | *5.00* | ..... | *5.00* | ..... | ..... | ..... |
| 7033 | ..... | ..... | 11.90 | ..... | ..... | ..... | 8.89 | ..... | 8.89 | ..... | ..... | ..... |
| 7052 | ..... | ..... | 11.10 | ..... | ..... | ..... | 8.49 | ..... | 8.49 | ..... | ..... | ..... |
| ..... | ..... | ..... | *11.00* | ..... | ..... | ..... | *8.50* | ..... | *8.50* | ..... | ..... | ..... |
| 7055 | ..... | ..... | 10.95 | ..... | ..... | ..... | 8.86 | ..... | 8.86 | ..... | ..... | ..... |
| ..... | ..... | ..... | *11.00* | ..... | ..... | ..... | *8.50* | ..... | *8.50* | ..... | ..... | ..... |
| 6944 | ..... | ..... | **6.85** | ..... | ..... | ..... | 7.22 | ..... | **7.22** | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *8.00* | ..... | *8.00* | ..... | ..... | ..... |

*7035—58% fine.
*7040—55% fine.
*6709—71% fine.
*6806—76% fine.
*6883—81% fine.
*7000—56% fine.
*7033—75% fine.
*7052—58% fine.
*7055—63% fine.
*6944—56% fine.

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **California Fertilizer Wks., San Francisco, Cal.** | | |
| 6874 | Blood | T. J. Dofflemyer & Sons, Exeter | **58.70** |
| | *Guaranteed* | | *60.54* |
| 6910 | Blood | J. M. Thorniley, Los Angeles | **60.90** |
| | *Guaranteed* | | *62.74* |
| 6911* | Bone Meal | J. M. Thorniley, Los Angeles | 33.78 |
| | *Guaranteed* | | *35.60* |
| 6856* | Tankage | T. K. Vernon, Upland | 40.27 |
| 6863* | Tankage | G. A. Hanson Fruit Co., Upland | 40.44 |
| | *Guaranteed* | | *40.80* |
| | **Citrus Fertilizer Co., Los Angeles, Cal.** | | |
| 6597 | Doty's Fruiting | E. E. Cole, Redlands | 23.24 |
| 6624 | Doty's Fruiting | H. C. Lash, Rialto | 22.72 |
| 6681 | Doty's Fruiting | G. R. Tyler, Pomona | 24.76 |
| 6683 | Doty's Fruiting | G. R. Tyler, Pomona | 23.75 |
| 6808 | Doty's Fruiting | E. E. Cole, Redlands | 23.85 |
| | *Guaranteed* | | *21.90* |
| 6598 | Doty's Nursery | E. E. Cole, Redlands | 29.08 |
| 6682 | Doty's Nursery | G. R. Tyler, Pomona | **22.54** |
| 6684 | Doty's Nursery | G. R. Tyler, Pomona | 29.77 |
| 6807 | Doty's Nursery | E. E. Cole, Redlands | 29.19 |
| | *Guaranteed* | | *27.70* |
| 6625 | Doty's Special No. 1 | H. C. Lash, Rialto | 21.02 |
| | *Guaranteed* | | *20.40* |
| | **Cudahy Packing Co., Los Angeles, Cal.** | | |
| 6796 | Blood | J. H. Simpson, Covina | **59.75** |
| 6797 | Blood | J. H. Simpson, Covina | **55.43** |
| 6888 | Blood | Monte Vista Citrus Assn., Riverside | **59.98** |
| 6926 | Blood | H. H. Cushman, Covina | 63.20 |
| 6943 | Blood | Santiago Orange Growers' Assn., Orange | 63.62 |
| | *Guaranteed* | | *62.10* |
| 6727* | Bone Meal | C. L. Nickle, Glendora | 36.17 |
| | *Guaranteed* | | *34.80* |
| 6728* | Bone Meal | W. M. Warren, Covina | 36.35 |
| | *Guaranteed* | | *36.10* |
| 6986 | Cudahy's Special Lawn | Aggeler & Musser Seed Co., Los Angeles | 26.17 |
| | *Guaranteed* | | *26.80* |
| 7046 | Cudahy's Special Lawn | Park & Lichty, Pomona | 32.64 |
| | *Guaranteed* | | *28.80* |
| 6729* | Tankage "A" | W. M. Warren, Covina | 42.62 |
| | *Guaranteed* | | *44.00* |
| 6730* | Tankage "B" | W. M. Warren, Covina | 41.89 |
| 6786* | Tankage "B" | W. B. Glidden, Hollywood | **39.89** |

*6911—67% fine.
*6856—84% fine.
*6863—85% fine.
*6727—71% fine.
*6728—50% fine.
*6729—70% fine.
*6730—56% fine.
*6786—74% fine.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | Chlorin |
| 6874 | ..... | ..... | ..... | ..... | ..... | ..... | 12.76 | ..... | **12.76** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.16* | ..... | *13.16* | ..... | ..... | ..... |
| 6910 | ..... | ..... | ..... | ..... | ..... | ..... | 13.24 | ..... | **13.24** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.64* | ..... | *13.64* | ..... | ..... | ..... |
| 6911 | ..... | ..... | 19.10 | ..... | ..... | ..... | 3.77 | ..... | 3.77 | ..... | ..... | ..... |
| ..... | ..... | ..... | *20.00* | ..... | ..... | ..... | *4.00* | ..... | *4.00* | ..... | ..... | ..... |
| 6856 | ..... | ..... | 8.50 | ..... | ..... | ..... | 7.80 | ..... | 7.80 | ..... | ..... | ..... |
| ..... | ..... | ..... | 7.55 | ..... | ..... | ..... | 7.99 | ..... | 7.99 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *8.00* | ..... | *8.00* | ..... | ..... | ..... |
| 6597 | 6.77 | 1.28 | 8.05 | ..... | 1.66 | ..... | 1.56 | ..... | 3.22 | ..... | 2.82 | 5.55 |
| 6624 | 6.98 | 1.32 | 8.30 | ..... | 1.40 | ..... | 1.59 | ..... | 2.99 | ..... | 2.93 | 3.90 |
| 6681 | 6.59 | 1.36 | 7.95 | ..... | 1.65 | ..... | 1.89 | ..... | 3.54 | ..... | 3.02 | 1.62 |
| 6683 | 7.31 | 1.14 | 8.45 | ..... | 1.29 | ..... | 1.91 | ..... | 3.20 | ..... | 2.84 | 1.90 |
| 6808 | 6.95 | 0.90 | 7.85 | ..... | 1.44 | ..... | 1.81 | ..... | 3.25 | ..... | 3.35 | 1.75 |
| ..... | *7.00* | ..... | *7.00* | *Bn, Super, G, T* | *1.00* | ..... | *2.00* | *Bn, G, T* | *3.00* | *3.00* | *3.00* | ..... |
| 6598 | 6.91 | 1.34 | 8.15 | ..... | 2.69 | ..... | 2.21 | ..... | 4.90 | ..... | 1.80 | 2.05 |
| 6682 | 7.46 | 1.14 | 8.60 | ..... | 1.24 | ..... | 1.52 | ..... | **2.76** | ..... | 3.40 | 1.87 |
| 6684 | 5.91 | 2.24 | 8.15 | ..... | 2.54 | ..... | 2.50 | ..... | 5.04 | ..... | 1.78 | 2.92 |
| 6807 | 6.22 | 1.78 | 8.00 | ..... | 2.40 | ..... | 2.48 | ..... | 4.88 | ..... | 1.96 | 1.75 |
| ..... | *6.00* | | *6.00* | *Bn, Super, G, T* | *2.00* | ..... | *3.00* | *Bn, G, T* | *5.00* | *1.50* | *1.50* | ..... |
| 6625 | **6.57** | 1.78 | 8.35 | ..... | ..... | ..... | 3.07 | ..... | 3.07 | ..... | ..... | ..... |
| ..... | *8.00* | ..... | ..... | *Bn, Super, G, T* | ..... | ..... | *3.00* | *Bn, G, T* | *3.00* | ..... | ..... | ..... |
| 6796 | ..... | ..... | ..... | ..... | ..... | ..... | 12.99 | ..... | **12.99** | ..... | ..... | ..... |
| 6797 | ..... | ..... | ..... | ..... | ..... | ..... | 12.05 | ..... | **12.05** | ..... | ..... | ..... |
| 6888 | ..... | ..... | ..... | ..... | ..... | ..... | 13.04 | ..... | **13.04** | ..... | ..... | ..... |
| 6926 | ..... | ..... | ..... | ..... | ..... | ..... | 13.74 | ..... | 13.74 | ..... | ..... | ..... |
| 6943 | ..... | ..... | ..... | ..... | ..... | ..... | 13.83 | ..... | 13.83 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.50* | ..... | *13.50* | ..... | ..... | ..... |
| 6727 | ..... | ..... | 26.30 | ..... | ..... | ..... | 2.84 | ..... | 2.84 | ..... | ..... | ..... |
| ..... | ..... | ..... | *24.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 6728 | ..... | ..... | 22.10 | ..... | ..... | ..... | 3.74 | ..... | 3.74 | ..... | ..... | ..... |
| ..... | ..... | ..... | *23.00* | ..... | ..... | ..... | *3.50* | ..... | *3.50* | ..... | ..... | ..... |
| 6986 | ..... | ..... | 8.05 | ..... | ..... | ..... | 4.11 | ..... | 4.11 | ..... | **0.84** | 0.62 |
| ..... | ..... | ..... | *8.00* | *Organic Matter* | ..... | ..... | *4.00* | ..... | *4.00* | ..... | *2.00* | ..... |
| 7046 | ..... | ..... | 11.90 | ..... | ..... | ..... | 4.57 | ..... | 4.57 | ..... | **1.82** | 1.27 |
| ..... | ..... | ..... | *8.00* | *Organic Matter* | ..... | ..... | *4.00* | ..... | *4.00* | ..... | *4.00* | ..... |
| 6729 | ..... | ..... | **7.45** | ..... | ..... | ..... | 8.50 | ..... | 8.50 | ..... | ..... | ..... |
| ..... | ..... | ..... | *11.00* | ..... | ..... | ..... | *8.25* | ..... | *8.25* | ..... | ..... | ..... |
| 6730 | ..... | ..... | **6.70** | ..... | ..... | ..... | 8.34 | ..... | 8.34 | ..... | ..... | ..... |
| 6786 | ..... | ..... | 8.90 | ..... | ..... | ..... | 7.65 | ..... | **7.65** | ..... | ..... | ..... |

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Cudahy Packing Co.** (*Continued*). **Los Angeles, Cal.** | | |
| 6798* | Tankage "B" | S. S. Scofield, Azusa | 41.59 |
| 6887* | Tankage "B" | R. W. Hamlin, Glendora | 42.62 |
| 6890* | Tankage "B" | Placentia Fruit Co., Placentia | 44.65 |
| 6924* | Tankage "B" | H. H. Church, Covina | 42.51 |
| 6925* | Tankage "B" | Brearley Investment Co., Covina | 42.69 |
| 6927* | Tankage "B" | H. H. Cushman, Covina | 41.55 |
| 6928* | Tankage "B" | W. M. Warren, Covina | 42.39 |
| 6929* | Tankage "B" | J. C. Wright, Azusa | 42.02 |
| 6930* | Tankage "B" | Pomona Fruit Growers' Exchange, Pomona | 43.13 |
| 6995* | Tankage "B" | J. C. Wright, Azusa | 44.61 |
| 6996* | Tankage "B" | M. T. Durrell, Azusa | 45.68 |
| 6997* | Tankage "B" | M. T. Durrell, Azusa | **40.14** |
| 6999* | Tankage "B" | W. M. Warren, Covina | 41.47 |
| 7037* | Tankage "B" | B. L. King, Covina | 44.16 |
| 7050* | Tankage "B" | Geo. W. Richardson, Glendora | 41.65 |
| 7051* | Tankage "B" | Geo. W. Richardson, Glendora | 41.48 |
| | *Guaranteed* | | *42.25* |
| 6989* | Tankage Formula | Aggeler & Musser Seed Co., Los Angeles | 24.93 |
| | *Guaranteed* | | *25.50* |
| | **Diamond Fertilizer Co., Los Angeles, Cal.** | | |
| 6568* | Garbage Tankage | Thomas Dugan, Los Angeles | |
| | *Guaranteed* | | |
| | **Fruit Growers' Supply Co., Los Angeles, Cal.** | | |
| 6935* | Tankage | Chas. H. Low, Riverside | **29.48** |
| 6992* | Tankage | Chas. H. Low, Riverside | 34.11 |
| | *Guaranteed* | | *32.00* |
| 6991* | Tankage | Dr. G. L. Hutchinson, Los Angeles | 40.44 |
| 7013* | Tankage | Mrs. L. S. Poage, Azusa | **39.14** |
| | *Guaranteed* | | *42.20* |
| 7034* | Tankage | Indian Hills Citrus Assn., North Pomona | 39.32 |
| | *Guaranteed* | | *39.88* |
| 7042* | Tankage | Chas. H. Low, Riverside | 38.55 |
| | *Guaranteed* | | *35.50* |
| 7044* | Tankage | A. F. Call Estate, Corona | 39.23 |
| | *Guaranteed* | | *37.28* |
| | **Germain Seed & Plant Co., Los Angeles, Cal.** | | |
| 6982* | Nuvida Lawn and Garden | Manufacturer's Warehouse | 27.58 |
| | *Guaranteed* | | *25.40* |

*6798—83% fine.
*6887—60% fine.
*6890—79% fine.
*6924—77% fine.
*6925—80% fine.
*6927—83% fine.
*6928—81% fine.
*6929—63% fine.
*6930—75% fine.
*6995—78% fine.
*6996—78% fine.
*6997—77% fine.
*6999—88% fine.
*7037—73% fine.
*7050—78% fine.
*7051—76% fine.
*6989—79% fine.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | Chlorin |
| 6798 | ..... | ..... | 8.25 | ..... | ..... | ..... | 8.14 | ..... | 8.14 | ..... | ..... | ..... |
| 6887 | ..... | ..... | **6.05** | ..... | ..... | ..... | 8.59 | ..... | 8.59 | ..... | ..... | ..... |
| 6890 | ..... | ..... | 9.10 | ..... | ..... | ..... | 8.70 | ..... | 8.70 | ..... | ..... | ..... |
| 6924 | ..... | ..... | 7.80 | ..... | ..... | ..... | 8.42 | ..... | 8.42 | ..... | ..... | ..... |
| 6925 | ..... | ..... | 10.20 | ..... | ..... | ..... | 8.08 | ..... | 8.08 | ..... | ..... | ..... |
| 6927 | ..... | ..... | 9.95 | ..... | ..... | ..... | 7.86 | ..... | **7.86** | ..... | ..... | ..... |
| 6928 | ..... | ..... | 7.75 | ..... | ..... | ..... | 8.40 | ..... | 8.40 | ..... | ..... | ..... |
| 6929 | ..... | ..... | **6.35** | ..... | ..... | ..... | 8.54 | ..... | 8.54 | ..... | ..... | ..... |
| 6930 | ..... | ..... | 9.75 | ..... | ..... | ..... | 8.25 | ..... | 8.25 | ..... | ..... | ..... |
| 6995 | ..... | ..... | 7.85 | ..... | ..... | ..... | 8.89 | ..... | 8.89 | ..... | ..... | ..... |
| 6996 | ..... | ..... | **6.80** | ..... | ..... | ..... | 9.30 | ..... | 9.30 | ..... | ..... | ..... |
| 6997 | ..... | ..... | 9.25 | ..... | ..... | ..... | 7.65 | ..... | **7.65** | ..... | ..... | ..... |
| 6999 | ..... | ..... | 13.55 | ..... | ..... | ..... | 7.27 | ..... | **7.27** | ..... | ..... | ..... |
| 7037 | ..... | ..... | 7.90 | ..... | ..... | ..... | 8.78 | ..... | 8.78 | ..... | ..... | ..... |
| 7050 | ..... | ..... | 9.15 | ..... | ..... | ..... | 8.01 | ..... | 8.01 | ..... | ..... | ..... |
| 7051 | ..... | ..... | 8.60 | ..... | ..... | ..... | 8.06 | ..... | 8.06 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.50* | ..... | ..... | ..... | *8.25* | ..... | *8.25* | ..... | ..... | ..... |
| 6989 | ..... | ..... | 7.70 | ..... | ..... | ..... | 4.44 | ..... | **4.44** | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.00* | ..... | ..... | ..... | *5.00* | ..... | *5.00* | ..... | ..... | ..... |
| 6568 | ..... | ..... | 2.45 | ..... | ..... | ..... | 3.20 | ..... | 3.20 | ..... | 1.36 | 1.97 |
| ..... | ..... | ..... | *3.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | *1.00* | ..... |
| 6935 | ..... | ..... | 7.10 | ..... | ..... | ..... | 5.57 | ..... | **5.57** | ..... | ..... | ..... |
| 6992 | ..... | ..... | 8.75 | ..... | ..... | ..... | 6.36 | ..... | 6.36 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *6.00* | ..... | *6.00* | ..... | ..... | ..... |
| 6991 | ..... | ..... | 13.65 | ..... | ..... | ..... | 7.02 | ..... | **7.02** | ..... | ..... | ..... |
| 7013 | ..... | ..... | 12.85 | ..... | ..... | ..... | 6.85 | ..... | **6.85** | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | ..... | ..... | ..... | *8.00* | ..... | *8.00* | ..... | ..... | ..... |
| 7034 | ..... | ..... | **11.60** | ..... | ..... | ..... | 7.09 | ..... | 7.09 | ..... | ..... | ..... |
| ..... | ..... | ..... | *13.28* | ..... | ..... | ..... | *6.95* | ..... | *6.95* | ..... | ..... | ..... |
| 7042 | ..... | ..... | 12.10 | ..... | ..... | ..... | 6.79 | ..... | 6.79 | ..... | ..... | ..... |
| ..... | ..... | ..... | *13.00* | ..... | ..... | ..... | *6.00* | ..... | *6.00* | ..... | ..... | ..... |
| 7044 | ..... | ..... | 11.60 | ..... | ..... | ..... | 7.07 | ..... | 7.07 | ..... | ..... | ..... |
| ..... | ..... | ..... | *11.90* | ..... | ..... | ..... | *6.58* | ..... | *6.58* | ..... | ..... | ..... |
| 6982 | 8.42 | 1.58 | 10.00 | ..... | 2.03 | ..... | 2.47 | ..... | 4.50 | ..... | ..... | ..... |
| ..... | *7.00* | *3.00* | *10.00* | ..... | *2.00* | ..... | *2.00* | *Bl* | *4.00* | ..... | ..... | ..... |

*6568—25% fine. In absence of market quotations no prices are given on Garbage Tankage.
*6935—86% fine. *7034—80% fine.
*6992—78% fine. *7042—78% fine.
*6991—80% fine. *7044—81% fine.
*7013—79% fine. *6982—Nitrogen given as nitric is guaranteed from cyanamid.

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **General Fertilizer Assn., San Bernardino, Cal.** | | |
| 6649 | Blood | B. L. Byer, Upland | 61 32 |
| | *Guaranteed* | | *59.80* |
| 6565 | G. F. A. Special | A. C. Denman & Sons, Redlands | 25.58 |
| 6723 | G. F. A. Special | Mrs. Amy Broadfield, Rialto | **20.73** |
| | *Guaranteed* | | *24.15* |
| 6799 | G. F. A. Special | W. F. Grow, Highland | 33.91 |
| | *Guaranteed* | | *35.30* |
| 6794 | G. F. A. No. 5 | W. F. Grow, Highland | 31.65 |
| | *Guaranteed* | | *33.10* |
| 6687 | Lawn and Rose | T. A. Blakeley, San Bernardino | 18.50 |
| | *Guaranteed* | | *19.60* |
| 6556 | Nitrate of Lime | E. B. Chapin, Ontario | 44.57 |
| | *Guaranteed* | | *42.94* |
| 6805 | Nitrate of Soda | J. Henry Reynolds, Redlands | 56.66 |
| | *Guaranteed* | | *57.00* |
| 6686* | Special Mixed | N. L. Mitchell, Ontario | 25.93 |
| | *Guaranteed* | | *24.12* |
| 6895* | Special Mixed | D. B. Lee, Ontario | 34.26 |
| | *Guaranteed* | | *35.19* |
| 7001* | Special Mixture | L. V. W. Brown, Riverside | 24.80 |
| | *Guaranteed* | | *24.60* |
| 6559* | Tankage | G. T. Henslee, Highland | **35.77** |
| | *Guaranteed* | | *43.75* |
| 6685* | Tankage | N. L. Mitchell, Ontario | 34.03 |
| | *Guaranteed* | | *35.22* |
| 6557* | Tankage and Bone | H. L. Salisbury, Alta Loma | 20.82 |
| | *Guaranteed* | | *19.80* |
| | **Globe Grain & Milling Co., Los Angeles, Cal.** | | |
| 6917 | Bat Guano | Jerome Reynolds, et al, Covina | 57.05 |
| | *Guaranteed* | | *52.45* |
| 6981 | Bat Guano | Manufacturer's Warehouse | 57.09 |
| | *Guaranteed* | | *59.67* |
| 6814 | Blood | Warehouse at Colton | 58.88 |
| | *Guaranteed* | | *59.80* |
| 6854 | Blood | G. A. Hanson Fruit Co., Upland | **62.70** |
| | *Guaranteed* | | *67.16* |
| 6970 | Blood | Manufacturer's Warehouse | 62.10 |
| | *Guaranteed* | | *62.10* |
| 6968* | Bone Meal Raw | Manufacturer's Warehouse | 38.96 |
| | *Guaranteed* | | *31.72* |
| 6879* | Bone Meal Steamed | Globe Mills, Fullerton | 37.10 |
| 6969* | Bone Meal Steamed | Manufacturer's Warehouse | 38.25 |
| | *Guaranteed* | | *34.80* |
| 6965 | Cotton Seed Meal | Manufacturer's Warehouse | 27.50 |
| | *Guaranteed* | | *26.40* |
| 6964* | Fish Meal | Manufacturer's Warehouse | **42.92** |
| | *Guaranteed* | | *45.20* |

*6686—No statement of derivation. In violation of California Fertilizer Act.
*6895—66% fine. *6559—77% fine.
*7001—65% fine. *6685—71% fine.
*6557—52% fine as tankage. Apparently contains some garbage tankage.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | |
| 6649 | ..... | ..... | ..... | ..... | ..... | ..... | 13.33 | ..... | 13.33 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.00* | ..... | *13.00* | ..... | ..... | ..... |
| 6565 | ..... | ..... | 11.30 | ..... | 0.94 | ..... | 2.49 | ..... | 3.43 | 0.88 | 0.88 | ..... |
| 6723 | ..... | ..... | **10.05** | ..... | 1.08 | ..... | 1.43 | ..... | **2.51** | 1.29 | 1.29 | ..... |
| ..... | ..... | ..... | *12.00* | *Bn, G* | *1.00* | ..... | *2.00* | *Bl, Bn, G* | *300* | ..... | *0.75* | ..... |
| 6799 | ..... | ..... | 11.90 | ..... | ..... | ..... | 4.60 | ..... | **4.60** | 2.04 | 2.04 | ..... |
| ..... | ..... | ..... | *12.00* | *Bn, G* | ..... | ..... | *5.00* | *Bl, Bn, G* | *5.00* | ..... | *1.50* | ..... |
| 6794 | 6.91 | 6.94 | 13.85 | ..... | 0.39 | ..... | 3.55 | ..... | **3.94** | ..... | 2.08 | ..... |
| ..... | *6.00* | *6.00* | *12.00* | *Bn, G* | *2.00* | ..... | *3.00* | *Bl, Bn, G* | *5.00* | ..... | *1.50* | ..... |
| 6687 | 3.37 | 4.18 | 7.55 | ..... | 1.27 | ..... | 1.29 | ..... | 2.56 | ..... | **1.20** | ..... |
| ..... | *4.00* | *4.00* | *8.00* | *Bn, G* | *1.00* | ..... | *1.50* | *Bl, Bn, G* | *2.50* | ..... | *2.00* | ..... |
| 6556 | ..... | ..... | ..... | ..... | 11.73 | ..... | ..... | ..... | 11.73 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *11.30* | ..... | ..... | ..... | *11.30* | ..... | ..... | ..... |
| 6805 | ..... | ..... | ..... | ..... | 14.91 | ..... | ..... | ..... | 14.91 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... |
| 6686 | ..... | ..... | 2.95 | ..... | 1.66 | ..... | 3.26 | ..... | 4.92 | ..... | 2.62 | 1.05 |
| ..... | ..... | ..... | *2.60* | ..... | *1.50* | ..... | *3.20* | ..... | *4.70* | ..... | *2.00* | ..... |
| 6895 | ..... | ..... | 6.95 | ..... | ..... | ..... | 6.68 | ..... | 6.68 | ..... | ..... | ..... |
| ..... | ..... | ..... | *6.90* | *Bn, T* | ..... | ..... | *6.90* | *Bl, Bn, T* | *6.90* | ..... | ..... | ..... |
| 7001 | ..... | ..... | 10.60 | ..... | ..... | ..... | 3.95 | ..... | 3.95 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | *Bl, Bn, T* | ..... | ..... | *4.00* | *Bl, Bn, T* | *4.00* | ..... | ..... | ..... |
| 6559 | ..... | ..... | 7.85 | ..... | ..... | ..... | 6.88 | ..... | **6.88** | ..... | ..... | ..... |
| ..... | ..... | ..... | *9.70* | ..... | ..... | ..... | *8.40* | ..... | *8.40* | ..... | ..... | ..... |
| 6685 | ..... | ..... | 9.95 | ..... | ..... | ..... | 6.15 | ..... | 6.15 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.40* | ..... | ..... | ..... | *6.35* | ..... | *6.35* | ..... | ..... | ..... |
| 6557 | ..... | ..... | 8.00 | ..... | ..... | ..... | 3.24 | ..... | 3.24 | ..... | 0.96 | 1.00 |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | *1.00* | ..... |
| 6917 | ..... | ..... | 3.00 | ..... | ..... | 1.87 | 11.35 | ..... | 13.22 | ..... | 1.59 | ..... |
| ..... | ..... | ..... | *3.26* | ..... | ..... | ..... | *11.92* | ..... | *11.92* | ..... | *1.31* | ..... |
| 6981 | ..... | ..... | 3.90 | ..... | 0.62 | 2.85 | 8.71 | ..... | 12.18 | ..... | 2.07 | ..... |
| ..... | ..... | ..... | *4.00* | ..... | ..... | ..... | *12.27* | ..... | *12.27* | ..... | *2.08* | ..... |
| 6814 | ..... | ..... | ..... | ..... | ..... | ..... | 12.80 | ..... | 12.80 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.00* | ..... | *13.00* | ..... | ..... | ..... |
| 6854 | ..... | ..... | ..... | ..... | ..... | ..... | 13.63 | ..... | **13.63** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *14.60* | ..... | *14.60* | ..... | ..... | ..... |
| 6970 | ..... | ..... | ..... | ..... | ..... | ..... | 13.50 | ..... | 13.50 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.50* | ..... | *13.50* | ..... | ..... | ..... |
| 6968 | ..... | ..... | 23.20 | ..... | ..... | ..... | 4.11 | ..... | 4.11 | ..... | ..... | ..... |
| ..... | ..... | ..... | *21.80* | ..... | ..... | ..... | *2.75* | ..... | *2.75* | ..... | ..... | ..... |
| 6879 | ..... | ..... | 24.80 | ..... | ..... | ..... | 3.36 | ..... | 3.36 | ..... | ..... | ..... |
| 6969 | ..... | ..... | 24.90 | ..... | ..... | ..... | 3.60 | ..... | 3.60 | ..... | ..... | ..... |
| ..... | ..... | ..... | *24.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 6965 | ..... | ..... | 2.90 | ..... | ..... | ..... | 6.25 | ..... | 6.25 | ..... | 1.67 | ..... |
| ..... | ..... | ..... | *3.00* | ..... | ..... | ..... | *6.00* | ..... | *6.00* | ..... | *1.50* | ..... |
| 6964 | ..... | ..... | 9.40 | ..... | ..... | ..... | 8.26 | ..... | **8.26** | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *9.00* | ..... | *9.00* | ..... | ..... | ..... |

*6968—47% fine. *6969—58% fine.
*6879—55% fine. *6964—61% fine.

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Globe Grain & Milling Co.** (*Continued*). **Los Angeles, Cal.** | | |
| 6967* | Fish Meal | Manufacturer's Warehouse | 43.98 |
| | *Guaranteed* | | *42.65* |
| 6972* | Garbage Tankage | Manufacturer's Warehouse | |
| | *Guaranteed* | | |
| 6921 | Globe Special | L. H. Root, Covina | 27.32 |
| 6966 | Globe Special | Manufacturer's Warehouse | 27.36 |
| | *Guaranteed* | | *28.10* |
| 6980 | Sulfate of Ammonia | Manufacturer's Warehouse | 78.36 |
| | *Guaranteed* | | *77.90* |
| 6880 | Superphosphate | Globe Mills, Fullerton | 16.47 |
| | *Guaranteed* | | *15.98* |
| 6861 | Superphosphate | G. A. Hanson Fruit Co., Upland | 16.94 |
| | *Guaranteed* | | *16.45* |
| 6731* | Tankage | G. W. Lindsay, Chino | 41.50 |
| 6862* | Tankage | G. A. Hanson Fruit Co., Upland | 44.01 |
| | *Guaranteed* | | *42.25* |
| 6855* | Tankage | | 33.31 |
| | *Guaranteed* | | *32.70* |
| 6881* | Tankage | Globe Mills, Fullerton | 33.94 |
| | *Guaranteed* | | *34.52* |
| 6971* | Tankage | Manufacturer's Warehouse | 37.72 |
| | *Guaranteed* | | *37.70* |
| 6979* | Tankage | Manufacturer's Warehouse | 33.85 |
| | *Guaranteed* | | *32.70* |
| | **Hauser Packing Co., Los Angeles, Cal.** | | |
| 6726 | Blood | W. H. Wiley, Glendora | 63.76 |
| 6946 | Blood | E. D. Barry, Los Angeles | 62.84 |
| | *Guaranteed* | | *63.94* |
| 6831 | Blood | E. N. Nahmens, Redlands | **64.86** |
| | *Guaranteed* | | *66.38* |
| 6907* | Bone Meal | H. C. Meek, Upland | 35.18 |
| | *Guaranteed* | | *34.80* |
| 7045* | Bone Meal | Geo. W. Fuhr, Azusa | 39.49 |
| | *Guaranteed* | | *37.50* |
| 6711 | Special Mixture | W. M. Baird, Duarte | 25.24 |
| | *Guaranteed* | | *23.80* |
| 6990* | Special Mixture | H. C. Meek, Upland | 45.71 |
| | *Guaranteed* | | *46.80* |
| 7015 | Special Mixture | Geo. W. Fuhr, Azusa | 28.24 |
| | *Guaranteed* | | *28.60* |
| 6553* | Tankage | J. M. Riley Fruit Co., Covina | 48.70 |
| 6906* | Tankage | H. C. Meek, Upland | **43.05** |
| 6913* | Tankage | W. H. Wiley, Glendora | 45.27 |
| 6914* | Tankage Big Gun | Mrs. J. M. Riley, Los Angeles | **44.95** |
| 6940* | Tankage Big Gun | R. T. Nelson, Upland | **43.54** |

*6967—82% fine.

*6972—66% fine. In absence of market quotations no prices are given on Garbage Tankage.

*6731—79% fine.

*6862—81% fine.

*6855—70% fine.

*6881—53% fine.

*6971—76% fine.

*6979—77% fine.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | Chlorin |
| 6967 | ..... | ..... | 10.85 | ..... | ..... | ..... | 8.27 | ..... | 8.27 | ..... | .. | ..... |
| ..... | ..... | ..... | *7.50* | ..... | ..... | ..... | *8.50* | ..... | *8.50* | ..... | .. .. | ..... |
| 6972 | ..... | ..... | 2.45 | ..... | ..... | ..... | 3.29 | ..... | 3.29 | ..... | 1.34 | 1.37 |
| ..... | ..... | ..... | *2.50* | ..... | ..... | ..... | *2.75* | ..... | *2.75* | ..... | *1.25* | ..... |
| 6921 | 8.80 | 1.40 | 10.20 | ..... | 2.17 | 0.88 | 1.11 | ..... | 4.16 | ..... | 1.67 | 0.87 |
| 6966 | 8.99 | 1.26 | 10.25 | ..... | 1.97 | 0.85 | 1.31 | ..... | 4.13 | ..... | 1.65 | 0.65 |
| ..... | ..... | ..... | *10.00* | *Bat G, Bn, Super, T* | ..... | ..... | *4.00* | *Bat G, Bl, Bn, T* | *4.00* | ..... | *1.50* | ..... |
| 6980 | ..... | ..... | ..... | ..... | ..... | 20.62 | ..... | ..... | 20.62 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | *20.50* | ..... | ..... | *20.50* | ..... | ..... | ..... |
| 6880 | 17.52 | 0.28 | 17.80 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *17.00* | *1.00* | *18.00* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 6861 | 18.02 | 0.38 | 18.40 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *17.50* | *0.35* | *17.85* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 6731 | ..... | ..... | 8.05 | ..... | ..... | ..... | 8.15 | ..... | 8.15 | ..... | ..... | ..... |
| 6862 | ..... | ..... | 7.55 | ..... | ..... | ..... | 8.80 | ..... | 8.80 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.50* | ..... | ..... | ..... | *8.25* | ..... | *8.25* | ..... | ..... | ..... |
| 6855 | ..... | ..... | 17.60 | ..... | ..... | ..... | 4.77 | ..... | 4.77 | ..... | ..... | ..... |
| ..... | ..... | ..... | *20.00* | ..... | ..... | ..... | *4.25* | ..... | *4.25* | ..... | ..... | ..... |
| 6881 | ..... | ..... | 18.00 | ..... | ..... | ..... | 4.85 | ..... | 4.85 | ..... | ..... | ..... |
| ..... | ..... | ..... | *18.57* | ..... | ..... | ..... | *4.89* | ..... | *4.89* | ..... | ..... | ..... |
| 6971 | ..... | ..... | 12.15 | ..... | ..... | ..... | 6.64 | ..... | 6.64 | ..... | ..... | ..... |
| ..... | ..... | ..... | *13.00* | ..... | ..... | ..... | *6.50* | ..... | *6.50* | ..... | ..... | ..... |
| 6979 | ..... | ..... | **17.30** | ..... | ..... | ..... | 4.94 | ..... | 4.94 | ..... | ..... | ..... |
| ..... | ..... | ..... | *20.00* | ..... | ..... | ..... | *4.25* | ..... | *4.25* | ..... | ..... | ..... |
| 6726 | ..... | ..... | ..... | ..... | ..... | ..... | 13.86 | ..... | 13.86 | ..... | ..... | ..... |
| 6946 | ..... | ..... | ..... | ..... | ..... | ..... | 13.66 | ..... | 13.66 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.90* | ..... | *13.90* | ..... | ..... | ..... |
| 6831 | ..... | ..... | ..... | ..... | ..... | ..... | 14.10 | ..... | **14.10** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *14.43* | ..... | *14.43* | ..... | ..... | ..... |
| 6907 | ..... | ..... | 25.60 | ..... | ..... | ..... | 2.76 | ..... | 2.76 | ..... | ..... | ..... |
| ..... | ..... | ..... | *24.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 7045 | ..... | ..... | 27.60 | ..... | ..... | ..... | 3.33 | ..... | 3.33 | ..... | ..... | ..... |
| ..... | ..... | ..... | *27.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 6711 | ..... | ..... | 17.50 | ..... | ..... | ..... | 1.93 | ..... | 1.93 | 1.00 | 1.00 | ..... |
| ..... | ..... | ..... | *18.00* | *Bn, T* | ..... | ..... | *1.50* | *Bl, Bn, T* | *1.50* | *1.00* | *1.00* | ..... |
| 6990 | ..... | ..... | 5.65 | ..... | ..... | ..... | 9.49 | ..... | **9.49** | ..... | ..... | ..... |
| ..... | ..... | ..... | *4.00* | *Bn, T* | ..... | ..... | *10.00* | *Bl, Bn, T* | *10.00* | ..... | ..... | ..... |
| 7015 | ..... | ..... | 9.80 | ..... | ..... | ..... | 4.07 | ..... | 4.07 | 1.51 | 1.51 | 0.70 |
| ..... | ..... | ..... | *10.00* | *Bn, T* | ..... | ..... | *4.00* | *Bl, Bn, T* | *4.00* | *2.00* | *2.00* | ..... |
| 6553 | ..... | ..... | 4.20 | ..... | ..... | ..... | 10.40 | ..... | 10.40 | .. .. | ..... | ..... |
| 6906 | ..... | ..... | 5.50 | ..... | ..... | ..... | 8.91 | ..... | **8.91** | ..... | ..... | ..... |
| 6913 | ..... | ..... | 6.40 | ..... | ..... | ..... | 9.27 | ..... | **9.27** | ..... | ..... | ..... |
| 6914 | .. .. | ..... | 6.45 | ..... | ..... | ..... | 9.19 | ..... | **9.19** | .. .. | ..... | ..... |
| 6940 | ..... | ..... | 6.45 | ..... | ..... | ..... | 8.87 | ..... | **8.87** | ..... | ..... | ..... |

*6907—57% fine.
*7045—56% fine.
*6990—66% fine.
*6553—72% fine.

*6906—62% fine.
*6913—66% fine.
*6914—65% fine.
*6940—65% fine.

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Hauser Packing Co.** (*Continued*). **Los Angeles, Cal.** | | |
| 6945* | Tankage Big Gun | Harry Dameral, et al, Covina | **43.36** |
| 6949* | Tankage | F. L. Hepner, Covina | **42.54** |
| 7016 | Tankage | R. T. Nelson, Upland | **44.41** |
| 7049* | Tankage | R. T. Nelson, Upland | 45.16 |
| | *Guaranteed* | | *46.80* |
| 6832* | Tankage | E. N. Nahmens, Redlands | 40.20 |
| 6869* | Tankage | West Highland Citrus Assn., Highland | 39.75 |
| 6908* | Tankage | B. W. Holden, et al, Upland | **38.73** |
| 6912* | Tankage | W. R. Eichhoff, Azusa | 40.28 |
| 6957* | Tankage | W. J. Worsham, San Dimas | 40.44 |
| 6974* | Tankage | H. T. Himrod, Pomona | **37.73** |
| 6975* | Tankage | C. F. Lawrence, Pomona | **36.16** |
| 6977* | Tankage | W. B. Bayless, Los Angeles | **37.92** |
| 7014* | Tankage | Geo. W. Fuhr, Azusa | 39.33 |
| | *Guaranteed* | | *40.80* |
| 6958* | Tankage | L. H. Bixby, Lordsburg | 38.22 |
| | *Guaranteed* | | *39.20* |
| | **Hawaiian Fertilizer Co., Ltd., San Francisco, Cal.** | | |
| 7039 | Bone Tankage | D. C. Tyler, Highland | 33.94 |
| | *Guaranteed* | | *33.00* |
| | **Mountain Copper Co., San Francisco, Cal.** | | |
| 6773 | Mixed 3–10–2 | Union Commission Co., Santa Barbara | 23.75 |
| | *Guaranteed* | | *23.23* |
| 7054 | Superphosphate | J. B. Bryan, Lemon Grove | 17.43 |
| | *Guaranteed* | | *16.69* |
| | **Pacific Bone Coal & Fertilizing Co., San Francisco, Cal.** | | |
| 6747 | Blood | G. G. Riley, Rialto | **59.34** |
| | *Guaranteed* | | *62.84* |
| 6793 | Blood | J. H. Simpson, Covina | **60.44** |
| | *Guaranteed* | | *65.23* |
| 6795 | Blood | W. M. Warren, Covina | 61.00 |
| | *Guaranteed* | | *61.55* |
| 6567* | Bone Meal | Monte Vista Citrus Assn., Riverside | 36.01 |
| 6724* | Bone Meal | A. L. Wright, Jr., Los Angeles | 37.18 |
| 6781* | Bone Meal | Duffill & Haskell, Los Angeles | 37.58 |
| | *Guaranteed* | | *34.80* |
| 6620* | Bone Meal | Bloomington Fruit Assn., Bloomington | 38.47 |
| | *Guaranteed* | | *37.41* |

*6945—68% fine.
*6949—65% fine.
*7016—65% fine.
*7049—71% fine.
*6832—64% fine.
*6869—61% fine.
*6908—67% fine.
*6912—68% fine.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | Chlorin |
| 6945 | ..... | ..... | 6.50 | ..... | ..... | ..... | 8.82 | ..... | **8.82** | ..... | ..... | ..... |
| 6949 | ..... | ..... | 6.90 | ..... | ..... | ..... | 8.57 | ..... | **8.57** | ..... | ..... | ..... |
| 7016 | ..... | ..... | 6.30 | ..... | ..... | ..... | 9.09 | ..... | **9.09** | ..... | ..... | ..... |
| 7049 | ..... | ..... | 5.30 | ..... | ..... | ..... | 9.42 | ..... | **9.42** | ..... | ..... | ..... |
| ..... | ..... | ..... | *4.00* | ..... | ..... | ..... | *10.00* | ..... | *10.00* | ..... | ..... | ..... |
| 6832 | ..... | ..... | 8.90 | ..... | ..... | ..... | 7.72 | ..... | **7.72** | ..... | ..... | ..... |
| 6869 | ..... | ..... | 7.50 | ..... | ..... | ..... | 7.84 | ..... | 7.84 | ..... | ..... | ..... |
| 6908 | ..... | ..... | 9.00 | ..... | ..... | ..... | 7.37 | ..... | **7.37** | ..... | ..... | ..... |
| 6912 | ..... | ..... | 8.70 | ..... | ..... | ..... | 7.77 | ..... | 7.77 | ..... | ..... | ..... |
| 6957 | ..... | ..... | 8.80 | ..... | ..... | ..... | 7.79 | ..... | 7.79 | ..... | ..... | ..... |
| 6974 | ..... | ..... | 7.95 | ..... | ..... | ..... | 7.31 | ..... | **7.31** | ..... | ..... | ..... |
| 6975 | ..... | ..... | 7.85 | ..... | ..... | ..... | 6.97 | ..... | **6.97** | ..... | ..... | ..... |
| 6977 | ..... | ..... | 8.10 | ..... | ..... | ..... | 7.33 | ..... | **7.33** | ..... | ..... | ..... |
| 7014 | ..... | ..... | 7.60 | ..... | ..... | ..... | 7.73 | ..... | **7.73** | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *8.00* | ..... | *8.00* | ..... | ..... | ..... |
| 6958 | ..... | ..... | 11.35 | ..... | ..... | ..... | 6.88 | ..... | 6.88 | ..... | ..... | ..... |
| ..... | ..... | ..... | *12.00* | ..... | ..... | ..... | *7.00* | ..... | *7.00* | ..... | ..... | ..... |
| 7039 | ..... | ..... | **18.50** | ..... | ..... | ..... | 4.77 | ..... | 4.77 | ..... | ..... | ..... |
| ..... | ..... | ..... | *22.00* | *Bn, Super, T* | ..... | ..... | *4.00* | *Bl, Bn, G, T* | *4.00* | ..... | ..... | ..... |
| 6773 | 9.52 | 0.48 | 10.00 | ..... | 2.10 | ..... | 1.10 | ..... | 3.20 | 1.93 | 1.93 | 0.75 |
| ..... | *10.00* | *0.25* | *10.25* | *Phosphate of Lime* | *2.00* | ..... | *1.00* | *Bl* | *3.00* | *2.00* | *2.00* | ..... |
| 7054 | 18.54 | 0.36 | 18.90 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *17.75* | *0.25* | *18.00* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 6747 | ..... | ..... | ..... | ..... | ..... | ..... | 12.90 | ..... | **12.90** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.66* | ..... | *13.66* | ..... | ..... | ..... |
| 6793 | ..... | ..... | ..... | ..... | ..... | ..... | 13.14 | ..... | **13.14** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *14.18* | ..... | *14.18* | ..... | ..... | ..... |
| 6795 | ..... | ..... | ..... | ..... | ..... | ..... | 13.26 | ..... | 13.26 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.38* | ..... | *13.38* | ..... | ..... | ..... |
| 6567 | ..... | ..... | 25.30 | ..... | ..... | ..... | 3.01 | ..... | 3.01 | ..... | ..... | ..... |
| 6724 | ..... | ..... | 24.40 | ..... | ..... | ..... | 3.46 | ..... | 3.46 | ..... | ..... | ..... |
| 6781 | ..... | ..... | 24.20 | ..... | ..... | ..... | 3.59 | ..... | 3.59 | ..... | ..... | ..... |
| ..... | ..... | ..... | *24.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 6620 | ..... | ..... | 22.90 | ..... | ..... | ..... | 4.06 | ..... | 4.06 | ..... | ..... | ..... |
| ..... | ..... | ..... | *22.50* | ..... | ..... | ..... | *3.90* | ..... | *3.90* | ..... | ..... | ..... |

*6957—73% fine.
*6974—66% fine. Sample perhaps not representative.
*6975—63% fine. Sample perhaps not representative.
*6977—58% fine.
*7014—79% fine.
*6958—78% fine.
*6567—64% fine.
*6724—51% fine.
*6781—61% fine.
*6620—60% fine.

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Pacific Bone, Coal & Fertilizing Co.** (*Continued*). **San Francisco, Cal.** | | |
| 6725* | Tankage, Bone | G. I. Lytle, Covina | 20.94 |
| 6750* | Tankage, Bone | W. C. Barnes, Rialto | 22.33 |
| | *Guaranteed* | | *20.00* |
| 6752* | Tankage | G. G. Wyllie, Rialto | 39.37 |
| | *Guaranteed* | | *40.00* |
| 6746 | Nitrate of Soda | G. G. Wyllie, Rialto | 57.72 |
| | *Guaranteed* | | *57.00* |
| 6718* | Salmon Scrap | Chas. H. Low, Riverside | 47.27 |
| | *Guaranteed* | | *45.65* |
| 6585* | Special, Sulfate of Ammonia and Bone Meal | A. F. Call Estate, Corona | 71.92 |
| 6766* | Special, Sulfate of Ammonia and Bone Meal | Fillmore Citrus Fruit Assn., Fillmore | 72.50 |
| 6780* | Special, Sulfate of Ammonia and Bone Meal | Duffill & Haskell, Los Angeles | 72.73 |
| | *Guaranteed* | | *73.10* |
| 6892 | Steamed Bone Meal and Sulfate of Ammonia | R. E. Williams, San Bernardino | 43.01 |
| 6960 | Steamed Bone Meal and Sulfate of Ammonia | Mrs. Detwiler, Sr., Alta Loma | 42.68 |
| | *Guaranteed* | | *40.50* |
| 6893 | Steamed Bone Meal and Sulfate of Ammonia | A. L. Wright, Los Angeles | 50.22 |
| 6916 | Steamed Bone Meal and Sulfate of Ammonia | W. M. Baird, Duarte | 50.96 |
| 6956 | Steamed Bone Meal and Sulfate of Ammonia | C. E. McLaughlin, Rialto | 50.55 |
| 6959 | Steamed Bone Meal and Sulfate of Ammonia | W. M. Baird, Duarte | 50.93 |
| | *Guaranteed* | | *51.80* |
| 6894 | Steamed Bone Meal and Sulfate of Ammonia | A. L. Wright, Los Angeles | 48.92 |
| | *Guaranteed* | | *46.00* |
| 6670 | Special No. 567 | W. B. Glidden, Hollywood | 25.08 |
| | *Guaranteed* | | *24.20* |
| 6769 | Sulfate of Ammonia | Teague-McKevett Co., Santa Paula | 79.04 |
| 6936 | Sulfate of Ammonia | A. F. Call Estate, Corona | 77.90 |
| 6938 | Sulfate of Ammonia | W. H. Jameson, Corona | 77.98 |
| 6939 | Sulfate of Ammonia | W. H. Jameson, Corona | 77.67 |
| | *Guaranteed* | | *77.00* |
| 7019 | Superphosphate | J. T. Bryan, Lemon Grove | 15.98 |
| | *Guaranteed* | | *16.69* |
| 6751* | Tankage | G. G. Wyllie, Rialto | 42.62 |
| 6853* | Tankage | Rialto Orange Co., Rialto | 41.42 |
| | *Guaranteed* | | *42.20* |
| 6884* | Tankage | C. A. Boettger, Redlands | 39.15 |
| | *Guaranteed* | | *40.01* |

*6725—91% fine.
*6750—85% fine.
*6752—75% fine.
*6718—62% fine.
*6585—Sample damp and decomposing.
*6766—Sample losing ammonia.
*6780—Sample losing ammonia.
*6751—87% fine.
*6853—83% fine.
*6884—74% fine.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | |
| 6725 | ..... | ..... | 16.40 | ..... | ..... | ..... | 2.15 | ..... | 2.15 | ..... | ..... | ..... |
| 6750 | ..... | ..... | 17.50 | ..... | ..... | ..... | 2.29 | ..... | 2.29 | ..... | ..... | ..... |
| ..... | ..... | ..... | *16.00* | ..... | ..... | ..... | *2.00* | ..... | *2.00* | ..... | ..... | ..... |
| 6752 | ..... | ..... | 19.50 | ..... | ..... | ..... | 4.96 | ..... | 4.96 | ..... | ..... | ..... |
| ..... | ..... | ..... | *20.00* | ..... | ..... | ..... | *5.00* | ..... | *5.00* | ..... | ..... | ..... |
| 6746 | ..... | ..... | ..... | ..... | 15.19 | ..... | ..... | ..... | 15.19 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... |
| 6718 | ..... | ..... | 5.55 | ..... | ..... | ..... | 9.86 | ..... | 9.86 | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.50* | ..... | ..... | ..... | *9.75* | ..... | *9.75* | ..... | ..... | ..... |
| 6585 | ..... | ..... | 2.10 | ..... | ..... | 18.43 | ..... | ..... | **18.43** | ..... | ..... | ..... |
| 6766 | ..... | ..... | 1.35 | ..... | ..... | 18.41 | 0.35 | ..... | 18.76 | ..... | ..... | ..... |
| 6780 | ..... | ..... | 2.45 | ..... | ..... | 18.26 | 0.30 | ..... | **18.56** | ..... | ..... | ..... |
| ..... | ..... | ..... | *1.00* | ..... | ..... | *19.00* | ..... | ..... | *19.00* | ..... | ..... | ..... |
| 6892 | ..... | ..... | 19.60 | ..... | ..... | 3.63 | 2.63 | ..... | 6.26 | ..... | ..... | ..... |
| 6960 | ..... | ..... | 19.80 | ..... | ..... | 3.16 | 2.92 | ..... | 6.08 | ..... | ..... | ..... |
| ..... | ..... | ..... | *18.00* | ..... | ..... | *3.50* | *2.50* | ..... | *6.00* | ..... | ..... | ..... |
| 6893 | ..... | ..... | 13.50 | ..... | ..... | 7.76 | 1.95 | ..... | **9.71** | ..... | ..... | ..... |
| 6916 | ..... | ..... | 13.45 | ..... | ..... | 7.63 | 2.24 | ..... | 9.87 | ..... | ..... | ..... |
| 6956 | ..... | ..... | 14.15 | ..... | ..... | 7.15 | 2.42 | ..... | **9.57** | ..... | ..... | ..... |
| 6959 | ..... | ..... | 14.55 | ..... | ..... | 7.20 | 2.38 | ..... | **9.58** | ..... | ..... | ..... |
| ..... | ..... | ..... | *14.00* | ..... | ..... | *8.00* | *2.00* | ..... | *10.00* | ..... | ..... | ..... |
| 6894 | ..... | ..... | 16.10 | ..... | ..... | 6.19 | 2.48 | ..... | 8.67 | ..... | ..... | ..... |
| ..... | ..... | ..... | *16.00* | ..... | ..... | *6.00* | *2.00* | ..... | *8.00* | ..... | ..... | ..... |
| 6670 | ..... | ..... | 10.80 | ..... | ..... | ..... | 3.05 | ..... | 3.05 | 1.94 | 1.94 | 0.72 |
| ..... | ..... | ..... | *10.00* | *Bn, T* | ..... | ..... | *3.00* | *Bl, Bn, T* | *3.00* | *2.00* | *2.00* | ..... |
| 6769 | ..... | ..... | ..... | ..... | ..... | 20.80 | ..... | ..... | 20.80 | ..... | ..... | ..... |
| 6936 | ..... | ..... | ..... | ..... | ..... | 20.50 | ..... | ..... | 20.50 | ..... | ..... | ..... |
| 6938 | ..... | ..... | ..... | ..... | ..... | 20.52 | ..... | ..... | 20.52 | ..... | ..... | ..... |
| 6939 | ..... | ..... | ..... | ..... | ..... | 20.44 | ..... | ..... | 20.44 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | *20.50* | ..... | ..... | *20.50* | ..... | ..... | ..... |
| 7019 | 17.00 | 0.30 | 17.30 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *17.75* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 6751 | ..... | ..... | 9.15 | ..... | ..... | ..... | 8.23 | ..... | 8.23 | ..... | ..... | ..... |
| 6853 | ..... | ..... | 9.20 | ..... | ..... | ..... | 7.95 | ..... | 7.95 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | ..... | ..... | ..... | *8.00* | ..... | *8.00* | ..... | ..... | ..... |
| 6884 | ..... | ..... | 10.30 | ..... | ..... | ..... | 7.26 | ..... | 7.26 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.65* | ..... | ..... | ..... | *7.40* | ..... | *7.40* | ..... | ..... | ..... |

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Pacific Bone, Coal & Fertilizer Co.** (*Continued*). **San Francisco, Cal.** | | |
| 6898* | Tankage | Mrs. O. F. Wright, Azusa | 45.60 |
| 6900* | Tankage | I. W. Haskell, Azusa | 46.20 |
| 6950* | Tankage | Claremont Citrus Assn., Claremont | **45.09** |
| 7041* | Tankage | Claremont Citrus Assn., Claremont | **44.80** |
| | *Guaranteed* | | *47.32* |
| 6955* | Tankage | C. E. McLaughlin, Rialto | 41.34 |
| | *Guaranteed* | | *40.80* |
| 7002* | Tankage | P. A. Demens, Alta Loma | 34.33 |
| | *Guaranteed* | | *32.50* |
| | **Pacific Guano & Fertilizer Co., San Francisco, Cal.** | | |
| 6743 | Blood | Harry Scott, Rialto | 64.26 |
| | *Guaranteed* | | *63.02* |
| 6775 | Blood | Frank Ford, et al, Pomona | 61.18 |
| | *Guaranteed* | | *59.80* |
| 6867 | Blood | J. D. Boley, et al, Highland | 60.54 |
| | *Guaranteed* | | *60.26* |
| 6998 | Blood | J. R. Elliott, Covina | 61.78 |
| | *Guaranteed* | | *61.96* |
| 6708* | Bone Meal | G. H. Wheeler, Rialto | 32.96 |
| | *Guaranteed* | | *32.50* |
| 6744* | Bone Meal | Harry Scott, Rialto | 39.97 |
| | *Guaranteed* | | *39.64* |
| 6868* | Bone Meal | J. D. Boley, et al, Highland | 39.94 |
| | *Guaranteed* | | *37.40* |
| 6690 | Chapman's Fall Application | H. Latimer, Ontario | 32.21 |
| 6809 | Chapman's Fall Application | Miss Dora Conkling, Redlands | 31.59 |
| | *Guaranteed* | | *31.50* |
| 6976* | Fish Crackling | C. E. McLaughlin, Rialto | 47.04 |
| | *Guaranteed* | | *48.00* |
| 7036 | Gaviota Special | Mrs. M. F. Ellis, Pomona | 31.33 |
| | *Guaranteed* | | *28.85* |
| 6745 | Special | Harry Scott, Rialto | 21.44 |
| | *Guaranteed* | | *21.50* |
| 6810 | Special | A. G. Johnson, Redlands | 24.83 |
| | *Guaranteed* | | *24.70* |
| 6811 | Special | A. G. Johnson, Redlands | 15.94 |
| | *Guaranteed* | | *15.93* |
| 6812 | Special | A. G. Johnson, Redlands | 27.64 |
| 6865 | Special | Hugh Latimer, Arlington | 28.75 |
| 6886 | Special | Hugh Latimer, Arlington | 27.88 |
| | *Guaranteed* | | *28.22* |
| 6866 | Special | Kankel & Latimer, Upland | 30.35 |
| | *Guaranteed* | | *29.80* |

*6898—77% fine.
*6900—81% fine.
*6950—81% fine.
*7041—79% fine.
*6955—81% fine.
*7002—81% fine.
*6708—98% fine.
*6744—50% fine.
*6868—44% fine.
*6976—85% fine.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | |
| 6898 | ..... | ..... | 6.05 | ..... | ..... | ..... | 9.40 | ..... | **9.40** | ..... | ..... | ..... |
| 6900 | ..... | ..... | 5.40 | ..... | ..... | ..... | 9.64 | ..... | 9.64 | ..... | ..... | ..... |
| 6950 | ..... | ..... | 5.70 | ..... | ..... | ..... | 9.34 | ..... | **9.34** | ..... | ..... | ..... |
| 7041 | ..... | ..... | 5.75 | ..... | ..... | 2.22 | 7.35 | ..... | **9.57** | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.50* | ..... | ..... | ..... | *9.88* | ..... | *9.88* | ..... | ..... | ..... |
| 6955 | ..... | ..... | 7.45 | ..... | ..... | ..... | 8.21 | ..... | 8.21 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *8.00* | ..... | *8.00* | ..... | ..... | ..... |
| 7002 | ..... | ..... | 14.10 | ..... | ..... | ..... | 5.56 | ..... | 5.56 | ..... | ..... | ..... |
| ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *5.00* | ..... | *5.00* | ..... | ..... | ..... |
| 6743 | ..... | ..... | ..... | ..... | ..... | ..... | 13.97 | ..... | 13.97 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.70* | ..... | *13.70* | ..... | ..... | ..... |
| 6775 | ..... | ..... | ..... | ..... | ..... | ..... | 13.30 | ..... | 13.30 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.00* | ..... | *13.00* | ..... | ..... | ..... |
| 6867 | ..... | ..... | ..... | ..... | ..... | ..... | 13.16 | ..... | 13.16 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.10* | ..... | *13.10* | ..... | ..... | ..... |
| 6998 | ..... | ..... | ..... | ..... | ..... | ..... | 13.43 | ..... | 13.43 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.47* | ..... | *13.47* | ..... | ..... | ..... |
| 6708 | ..... | ..... | 33.00 | ..... | ..... | ..... | 0.74 | ..... | 0.74 | ..... | ..... | ..... |
| ..... | ..... | ..... | *32.05* | ..... | ..... | ..... | *0.83* | ..... | *0.83* | ..... | ..... | ..... |
| 6744 | ..... | ..... | 18.60 | ..... | ..... | ..... | 5.28 | ..... | 5.28 | ..... | ..... | ..... |
| ..... | ..... | ..... | *19.80* | ..... | ..... | ..... | *4.96* | ..... | *4.96* | ..... | ..... | ..... |
| 6868 | ..... | ..... | 23.50 | ..... | ..... | ..... | 4.27 | ..... | 4.27 | ..... | ..... | ..... |
| ..... | ..... | ..... | *22.00* | ..... | ..... | ..... | *4.00* | ..... | *4.00* | ..... | ..... | ..... |
| 6690 | ..... | ..... | 17.60 | ..... | ..... | ..... | 1.03 | ..... | 1.03 | 11.84 | 11.84 | 1.12 |
| 6809 | ..... | ..... | 17.80 | ..... | ..... | ..... | 0.85 | ..... | 0.85 | 11.83 | 11.83 | 1.17 |
| ..... | ..... | ..... | *18.00* | *Bn, Super* | ..... | ..... | *0.75* | *Bn* | *0.75* | *12.00* | *12.00* | ..... |
| 6976 | ..... | ..... | 5.60 | ..... | ..... | ..... | 9.80 | ..... | 9.80 | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.71* | ..... | ..... | ..... | *10.00* | ..... | *10.00* | ..... | ..... | ..... |
| 7036 | 9.19 | 1.96 | 11.15 | ..... | 2.39 | ..... | 2.47 | ..... | 4.86 | 1.34 | 1.34 | 0.70 |
| ..... | ..... | ..... | *10.50* | *Bn, Super* | *1.50* | ..... | *3.00* | *Fs, G* | *4.50* | *0.50* | *0.50* | ..... |
| 6745 | ..... | ..... | 7.90 | ..... | 1.54 | ..... | 1.47 | ..... | 3.01 | 2.01 | 2.01 | 0.80 |
| ..... | ..... | ..... | *8.00* | *Bn, Super, G* | *1.50* | ..... | *1.50* | *Bl, Bn, Fs, G, T* | *3.00* | *2.00* | *2.00* | ..... |
| 6810 | ..... | ..... | 9.90 | ..... | 0.69 | ..... | 1.97 | ..... | 2.66 | 4.63 | 4.63 | 0.82 |
| ..... | ..... | ..... | *10.00* | *Bn, Super, G* | *0.50* | ..... | *2.00* | *Bl, Bn, Fs, G, T* | *2.50* | *5.00* | *5.00* | ..... |
| 6811 | ..... | ..... | 8.85 | ..... | ..... | ..... | 0.85 | ..... | 0.85 | ..... | **4.23** | 1.05 |
| ..... | ..... | ..... | *8.75* | *Bn, Super* | ..... | ..... | *0.75* | *Bn, T* | *0.75* | *4.75* | *4.75* | ..... |
| 6812 | 6.61 | 3.84 | 10.45 | ..... | 2.34 | ..... | 1.45 | ..... | 3.79 | ..... | 2.96 | 1.12 |
| 6865 | ..... | ..... | 10.50 | ..... | 2.65 | ..... | 1.37 | ..... | 4.02 | 3.20 | 3.20 | 0.92 |
| 6886 | 7.55 | 2.90 | 10.45 | ..... | 2.66 | ..... | 1.21 | ..... | 3.87 | ..... | 3.04 | 1.15 |
| ..... | ..... | ..... | *10.00* | *Bn, Super, G* | *2.30* | ..... | *1.70* | *Bn, G* | *4.00* | *3.00* | *3.00* | ... |
| 6866 | ..... | ..... | 10.75 | ..... | 1.11 | 1.17 | 2.73 | ..... | 5.01 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | *Bn, Super, G* | *1.00* | *1.00* | *3.00* | *Bl, Bn, Fs, G, T* | *5.00* | ..... | ..... | ..... |

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Pacific Guano & Fertilizer Co.** (*Continued*). **San Francisco, Cal.** | | |
| 7047 | Special | E. F. Struve, Pomona | 25.54 |
| | *Guaranteed* | | *23.70* |
| 6951 | Sulfate of Ammonia | Claremont Citrus Assn., Claremont | 77.52 |
| | *Guaranteed* | | *78.13* |
| 6789* | Tankage | H. M. Bradley, Riverside | 35.29 |
| | *Guaranteed* | | *35.08* |
| 6790* | Tankage | H. M. Bradley, Riverside | 35.67 |
| 6791* | Tankage | H. M. Bradley, Riverside | 35.79 |
| | *Guaranteed* | | *34.77* |
| | **Pacific Reduction Co., Los Angeles, Cal.** | | |
| 6704* | Garbage Tankage | A. B. White, Los Angeles | |
| | *Guaranteed* | | |
| 6737* | Organic Tankage | W. R. Slater, Ontario | |
| | *Guaranteed* | | |
| 6764* | Organic Tankage | G. I. Lytle, Covina | |
| | *Guaranteed* | | |
| | **San Antonio Meat Co., Pomona, Cal.** | | |
| 6705* | Tankage | A. L. Wright, Pomona | |
| | Sold on Station Analysis. | | |
| | **Southern California Fertilizer Co., Los Angeles, Cal.** | | |
| 6885* | Garbage Tankage | Mrs. James Fleming, San Bernardino | |
| 6891* | Garbage Tankage | B. S. Casey, Rialto | |
| 6903* | Garbage Tankage | J. H. Strait, Redlands | |
| 6919* | Garbage Tankage | G. W. Duley, Upland | |
| 6942* | Garbage Tankage | E. A. Zumbro, Riverside | |
| 7007* | Garbage Tankage | W. H. Jameson, Corona | |
| 7008* | Garbage Tankage | W. H. Jameson, Corona | |
| | *Guaranteed* | | |
| 6905* | Garbage Tankage | C. J. Barnes, Redlands | |
| | *Guaranteed* | | |
| 6937* | Garbage Tankage | A. F. Call Estate, Corona | |
| 7009* | Garbage Tankage | A. F. Call Estate, Corona | |
| 7010* | Garbage Tankage | A. F. Call Estate, Corona | |
| 7011* | Garbage Tankage | A. F. Call Estate, Corona | |
| 7012* | Garbage Tankage | A. F. Call Estate, Corona | |
| 7020* | Garbage Tankage | A. F. Call Estate, Corona | |
| | *Guaranteed* | | |

*6789—91% fine.

*6790—89% fine. *6791—93% fine.

*6704—33% fine. These goods bore no tags. In violation of the California Fertilizer Act. In absence of market quotations, no prices are given on Garbage Tankage.

*6737—31% fine. In absence of market quotations, no prices are given on Garbage Tankage.

*6764—66% fine. In absence of market quotations, no prices are given on Garbage Tankage.

*6705—82% fine.

*6885—36% fine. In absence of market quotations, no prices are given on Garbage Tankage.

*6891—36% fine. In absence of market quotations, no prices are given on Garbage Tankage.

*6903—39% fine. In absence of market quotations, no prices are given on Garbage Tankage.

*6919—32% fine. In absence of market quotations, no prices are given on Garbage Tankage.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | |
| 7047 | 6.71 | 4.94 | 11.65 | ..... | ..... | ..... | 2.36 | ..... | 2.36 | ..... | 4.67 | 1.27 |
| ..... | ..... | ..... | *11.00* | *Bn, Super, G* | ..... | ..... | *200* | *Bl, Bn, Fs, G, T* | *2.00* | *5.00* | *5.00* | |
| 6951 | ..... | ..... | ..... | ..... | ..... | 20.40 | ..... | ..... | 20.40 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | *20.56* | ..... | ..... | *20.56* | ..... | ..... | ..... |
| 6789 | ..... | ..... | 19.30 | ..... | ..... | ..... | 4.95 | ..... | 4.95 | ..... | ..... | ..... |
| ..... | ..... | ..... | *18.12* | ..... | ..... | ..... | *5.09* | ..... | *5.09* | ..... | ..... | ..... |
| 6790 | ..... | ..... | 19.90 | ..... | ..... | ..... | 4.94 | ..... | 4.94 | ..... | ..... | ..... |
| 6791 | ..... | ..... | 20.20 | ..... | ..... | ..... | 4.92 | ..... | 4.92 | ..... | ..... | ..... |
| ..... | ..... | ..... | *19.50* | ..... | ..... | ..... | *4.80* | ..... | *4.80* | ..... | ..... | ..... |
| 6704 | ..... | ..... | 2.40 | ..... | ..... | ..... | 3.02 | ..... | 3.02 | ..... | 1.59 | 1.52 |
| ..... | ..... | ..... | *3.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | *1.00* | ..... |
| 6737 | ..... | ..... | 2.40 | ..... | ..... | ..... | 2.84 | ..... | 2.84 | ..... | 1.43 | 1.15 |
| ..... | ..... | ..... | *2.75* | *Garbage* | ..... | ..... | *3.00* | *Garbage* | *3.00* | ..... | *1.25* | ..... |
| 6764 | ..... | ..... | 2.55 | ..... | ..... | ..... | 3.01 | ..... | 3.01 | ..... | 1.42 | 1.17 |
| ..... | ..... | ..... | *3.00* | *Garbage* | ..... | ..... | *2.75* | *Garbage* | *2.75* | ..... | *1.25* | ..... |
| 6705 | ..... | ..... | 6.55 | ..... | ..... | ..... | 9.32 | ..... | 9.32 | ..... | ..... | ..... |
| 6885 | ..... | ..... | 2.80 | ..... | ..... | ..... | 2.90 | ..... | 2.90 | ..... | 1.18 | 1.15 |
| 6891 | ..... | ..... | 3.10 | ..... | ..... | ..... | 3.04 | ..... | 3.04 | ..... | 1.18 | 1.75 |
| 6903 | ..... | ..... | 2.55 | ..... | ..... | ..... | 2.98 | ..... | 2.98 | ..... | 1.25 | 1.32 |
| 6919 | ..... | ..... | 2.10 | ..... | ..... | ..... | 2.94 | ..... | 2.94 | ..... | 1.40 | 1.37 |
| 6942 | ..... | ..... | 2.35 | ..... | ..... | ..... | 2.98 | ..... | 2.98 | ..... | 1.18 | 1.35 |
| 7007 | ..... | ..... | 3.15 | ..... | ..... | ..... | 3.08 | ..... | 3.08 | ..... | 1.02 | 1.35 |
| 7008 | ..... | ..... | 2.80 | ..... | ..... | ..... | 3.01 | ..... | 3.01 | ..... | 1.23 | 1.32 |
| ..... | ..... | ..... | *2.25* | ..... | ..... | ..... | *2.75* | ..... | *2.75* | ..... | *1.25* | ..... |
| 6905 | ..... | ..... | 3.00 | ..... | ..... | ..... | 3.09 | ..... | 3.09 | ..... | 1.35 | 1.20 |
| ..... | ..... | ..... | *2.25* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | *1.25* | ..... |
| 6937 | ..... | ..... | 1.80 | ..... | ..... | ..... | 2.93 | ..... | 2.93 | ..... | 1.33 | 1.25 |
| 7009 | ..... | ..... | 2.35 | ..... | ..... | ..... | 3.04 | ..... | 3.04 | ..... | 1.26 | 1.52 |
| 7010 | ..... | ..... | 2.15 | ..... | ..... | ..... | 2.85 | ..... | 2.85 | ..... | 1.25 | 1.47 |
| 7011 | ..... | ..... | 2.30 | ..... | ..... | ..... | 2.76 | ..... | 2.76 | ..... | 1.18 | 1.27 |
| 7012 | ..... | ..... | 2.15 | ..... | ..... | ..... | 2.70 | ..... | **2.70** | ..... | 1.24 | 1.37 |
| 7020 | ..... | ..... | 2.45 | ..... | ..... | ..... | 2.98 | ..... | 2.98 | ..... | 1.19 | 1.37 |
| ..... | ..... | ..... | *2.50* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | *1.00* | ..... |

*6942—39% fine. In absence of market quotations, no prices are given on Garbage Tankage.
*7007—45% fine. In absence of market quotations, no prices are given on Garbage Tankage.
*7008—44% fine. In absence of market quotations, no prices are given on Garbage Tankage.
*6905—36% fine. In absence of market quotations, no prices are given on Garbage Tankage.
*6937—33% fine. In absence of market quotations, no prices are given on Garbage Tankage.
*7009—44% fine. In absence of market quotations, no prices are given on Garbage Tankage.
*7010—43% fine. In absence of market quotations, no prices are given on Garbage Tankage.
*7011—45% fine. In absence of market quotations, no prices are given on Garbage Tankage.
*7012—43% fine. In absence of market quotations, no prices are given on Garbage Tankage.
*7020—46% fine. In absence of market quotations, no prices are given on Garbage Tankage.

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Standard Fertilizer Co., Los Angeles, Cal.** | | |
| 6963* | Fish | Factory | 47.68 |
| | *Guaranteed* | | *43.80* |
| 6961* | ———— | Factory | 25.82 |
| | *Guaranteed* | | *15.80* |
| 6962* | ———— | Factory | 40.97 |
| | *Guaranteed* | | *40.80* |
| 6978* | ———— | Factory | 15.32 |
| | *Guaranteed* | | *16.73* |
| | **Swift & Co., Chicago, Ill.** | | |
| 6785* | Tankage | Indian Hill Citrus Assn., North Pomona | **40.22** |
| | *Guaranteed* | | *46.04* |
| | **Union Superphosphate Co., San Francisco, Cal.** | | |
| 6779 | Superphosphate | Sparr Fruit Co., Fillmore | 17.63 |
| | *Guaranteed* | | *15.98* |
| | **Western Fertilizer Co., San Francisco, Cal.** | | |
| 6669 | Wizard | C. H. Nearpass, San Diego | 36.17 |
| | *Guaranteed* | | *35.90* |
| | **Western Meat Company, San Francisco, Cal.** | | |
| 6599 | Blood, Diamond H | J. H. Reynolds, Redlands | 63.94 |
| | *Guaranteed* | | *66.01* |
| 6612 | Blood, Diamond H | B. L. Byer, Upland | 66.19 |
| 6653 | Blood, Diamond H | B. L. Byer, Upland | 63.30 |
| | *Guaranteed* | | *64.40* |
| 6619 | Blood, Diamond H | J. H. Reynolds, Redlands | 63.89 |
| | *Guaranteed* | | *63.16* |
| 6628 | Blood, Diamond H | B. L. Byer, Upland | 56.67 |
| | *Guaranteed* | | *55.20* |
| 6646 | Blood, Diamond H | B. L. Byer, Upland | 65.41 |
| | *Guaranteed* | | *66.19* |
| 6735 | Blood, Diamond H | E. L. Koethen, Riverside | 63.94 |
| | *Guaranteed* | | *62.97* |
| 6800 | Blood, Diamond H | J. H. Reynolds, Redlands | 62.70 |
| | *Guaranteed* | | *63.71* |
| 6801 | Blood, Diamond H | J. H. Reynolds, Redlands | 62.70 |
| | *Guaranteed* | | *61.36* |
| 6802 | Blood, Diamond H | J. H. Reynolds, Redlands | 62.47 |
| | *Guaranteed* | | *62.74* |
| 6821 | Blood | B. L. Byer, Upland | **62.84** |
| | *Guaranteed* | | *64.45* |
| 6822 | Blood | B. L. Byer, Upland | **62.88** |
| | *Guaranteed* | | *64.17* |
| 6823 | Blood | B. L. Byer, Upland | 61.96 |
| | *Guaranteed* | | *62.47* |

*6963—49% fine.

*6961—70% fine. No statement of derivation, no brand name. In violation of California Fertilizer Act.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | |
| 6963 | ..... | ..... | 6.95 | ..... | ..... | ..... | 9.73 | ..... | 9.73 | ..... | ..... | ..... |
| ..... | ..... | ..... | *6.00* | ..... | ..... | ..... | *9.00* | ..... | *9.00* | ..... | ..... | ..... |
| 6961 | ..... | ..... | 9.60 | ..... | ..... | ..... | 4.34 | ..... | 4.34 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | ..... | ..... | ..... | *2.00* | ..... | *2.00* | ..... | ..... | ..... |
| 6962 | ..... | ..... | 8.30 | ..... | ..... | ..... | 7.99 | ..... | 7.99 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *8.00* | ..... | *8.00* | ..... | ..... | ..... |
| 6978 | 15.06 | 1.24 | **16.30** | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | ..... | ..... | *17.80* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 6785 | ..... | ..... | 11.20 | ..... | ..... | ..... | 7.36 | ..... | **7.36** | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.65* | ..... | ..... | ..... | *8.77* | ..... | *8.77* | ..... | ..... | ..... |
| 6779 | 18.76 | 0.34 | 19.10 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | *17.00* | *1.00* | *18.00* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 6669 | 8.70 | 1.20 | 9.90 | ..... | 6.02 | ..... | ..... | ..... | 6.02 | 4.38 | **4.38** | 0.67 |
| ..... | *9.00* | ..... | *9.00* | *Super* | *6.00* | ..... | ..... | ..... | *6.00* | *5.00* | *5.00* | |
| 6599 | ..... | ..... | ..... | ..... | ..... | ..... | 13.90 | ..... | **13.90** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *14.35* | ..... | *14.35* | ..... | ..... | ..... |
| 6612 | ..... | ..... | ..... | ..... | ..... | ..... | 14.39 | ..... | 14.39 | ..... | ..... | ..... |
| 6653 | ..... | ..... | ..... | ..... | ..... | ..... | 13.76 | ..... | 13.76 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *14.00* | ..... | *14.00* | ..... | ..... | ..... |
| 6619 | ..... | ..... | ..... | ..... | ..... | ..... | 13.89 | ..... | 13.89 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.73* | ..... | *13.73* | ..... | ..... | ..... |
| 6628 | ..... | ..... | ..... | ..... | ..... | ..... | 12.32 | ..... | 12.32 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *12.00* | ..... | *12.00* | ..... | ..... | ..... |
| 6646 | ..... | ..... | ..... | ..... | ..... | ..... | 14.22 | ..... | 14.22 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *14.39* | ..... | *14.39* | ..... | ..... | ..... |
| 6735 | ..... | ..... | ..... | ..... | ..... | ..... | 13.90 | ..... | 13.90 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.69* | ..... | *13.69* | ..... | ..... | ..... |
| 6800 | ..... | ..... | ..... | ..... | ..... | ..... | 13.63 | ..... | 13.63 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.85* | ..... | *13.85* | ..... | ..... | ..... |
| 6801 | ..... | ..... | ..... | ..... | ..... | ..... | 13.63 | ..... | 13.63 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.34* | ..... | *13.34* | ..... | ..... | ..... |
| 6802 | ..... | ..... | ..... | ..... | ..... | ..... | 13.58 | ..... | 13.58 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | 13.64 | ..... | **13.64** | ..... | ..... | ..... |
| 6821 | ..... | ..... | ..... | ..... | ..... | ..... | 13.66 | ..... | **13.66** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *14.01* | ..... | *14.01* | ..... | ..... | ..... |
| 6822 | ..... | ..... | ..... | ..... | ..... | ..... | 13.67 | ..... | **13.67** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.95* | ..... | *13.95* | ..... | ..... | ..... |
| 6823 | ..... | ..... | ..... | ..... | ..... | ..... | 13.47 | ..... | 13.47 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.58* | ..... | *13.58* | ..... | ..... | ..... |

*6962—67% fine. No statement of derivation, no brand name. In violation of California Fertilizer Act.
*6978—No statement of derivation, no brand name. In violation of California Fertilizer Act.
*6785—78% fine.

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Western Meat Co.** (*Continued*). **San Francisco, Cal.** | | |
| 6824 | Blood | B. L. Byer, Upland | **56.17** |
| | *Guaranteed* | | *57.96* |
| 6889 | Blood | Placentia Fruit Co., Placentia | **62.74** |
| | *Guaranteed* | | *64.31* |
| 6897 | Blood | J. S. Grepe, East Highlands | 61.41 |
| | *Guaranteed* | | *62.10* |
| 6920 | Blood | G. D. Tangeman, et al, San Dimas | **64.49** |
| | *Guaranteed* | | *66.19* |
| 6603* | Bone Meal, Diamond G | J. H. Reynolds, Redlands | 36.94 |
| 6630* | Bone Meal, Diamond G | B. L. Byer, Upland | 37.46 |
| | *Guaranteed* | | *36.79* |
| 6613* | Bone Meal, Diamond G | B. L. Byer, Upland | 33.95 |
| 6734* | Bone Meal, Diamond G | E. L. Koethen, Riverside | 34.70 |
| | *Guaranteed* | | *33.10* |
| 6601* | Bone Meal, Special | J. H. Reynolds, Redlands | **32.22** |
| | *Guaranteed* | | *34.72* |
| 6629 | Diamond A | B. L. Byer, Upland | 22.85 |
| | *Guaranteed* | | *22.45* |
| 6602 | Diamond D | J. H. Reynolds, Redlands | 29.70 |
| | *Guaranteed* | | *28.00* |
| 6820 | Nitrate of Soda | B. L. Byer, Upland | 57.08 |
| 6932 | Nitrate of Soda | Albers Olive Oil Co., Elsinore | 57.49 |
| | *Guaranteed* | | *57.00* |
| 6611 | Special | P. A. Demens, Alta Loma | 28.13 |
| 6636 | Special | B. L. Byer, Upland | 29.25 |
| 6758 | Special | Anaheim Citrus Fruit Assn., Anaheim | 28.06 |
| 6934 | Special | Albers Olive Oil Co., Elsinore | 27.34 |
| 7018 | Special | El Dorado Potato Growers' Assn., Placerville | 31.72 |
| 7056 | Special | Burdett K. Marvin, Riverside | 31.51 |
| | *Guaranteed* | | *28.60* |
| 6633* | Special | B. L. Byer, Upland | 35.61 |
| | *Guaranteed* | | *34.72* |
| 6634 | Special | B. L. Byer, Upland | 37.13 |
| | *Guaranteed* | | *35.60* |
| 6635 | Special | B. L. Byer, Upland | 30.94 |
| | *Guaranteed* | | *31.20* |
| 6647* | Special G | B. L. Byer, Upland | 34.13 |
| | *Guaranteed* | | *32.56* |
| 6650* | Special | B. L. Byer, Upland | 37.79 |
| | *Guaranteed* | | *38.30* |
| 6771 | Special | Johnson Fruit Co., Santa Barbara | 29.51 |
| | *Guaranteed* | | *28.54* |

*6603—67% fine. *6734—78% fine. *6647—75% fine as bone.
*6630—66% fine. *6601—50% fine. *6650—80% fine as tankage.
*6613—76% fine. *6633—62% fine.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | |
| 6824 | ..... | ..... | ..... | ..... | ..... | ..... | 12.21 | ..... | **12.21** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *12.60* | ..... | *12.60* | ..... | ..... | ..... |
| 6889 | ..... | ..... | ..... | ..... | ..... | ..... | 13.64 | ..... | 13.64 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.98* | ..... | *13.98* | ..... | ..... | ..... |
| 6897 | ..... | ..... | ..... | ..... | ..... | ..... | 13.35 | ..... | 13.35 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.50* | ..... | *13.50* | ..... | ..... | ..... |
| 6920 | ..... | ..... | ..... | ..... | ..... | ..... | 14.02 | ..... | **14.02** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *14.39* | ..... | *14.39* | ..... | ..... | ..... |
| 6603 | ..... | ..... | 27.60 | ..... | ..... | ..... | 2.75 | ..... | 2.75 | ..... | ..... | ..... |
| 6630 | ..... | ..... | 27.30 | ..... | ..... | ..... | 2.93 | ..... | 2.93 | ..... | ..... | ..... |
| ..... | ..... | ..... | *26.70* | ..... | ..... | ..... | *2.90* | ..... | *2.90* | ..... | ..... | ..... |
| 6613 | ..... | ..... | 29.90 | ..... | ..... | ..... | 1.60 | ..... | **1.60** | ..... | ..... | ..... |
| 6734 | ..... | ..... | 29.80 | ..... | ..... | ..... | 1.79 | ..... | 1.79 | ..... | ..... | ..... |
| ..... | ..... | ..... | *27.00* | ..... | ..... | ..... | *2.00* | ..... | *2.00* | ..... | ..... | ..... |
| 6601 | ..... | ..... | 20.50 | ..... | ..... | ..... | 3.13 | ..... | **3.13** | ..... | ..... | ..... |
| ..... | ..... | ..... | *20.00* | ..... | ..... | ..... | *3.80* | ..... | *3.80* | ..... | ..... | ..... |
| 6629 | **6.75** | 6.80 | 13.55 | ..... | ..... | ..... | 1.96 | ..... | 1.96 | ..... | 2.03 | 1.20 |
| ..... | *12.00* | *1.50* | *13.50* | *Bn, Super* | ..... | ..... | *2.00* | *Animal Matter* | *2.00* | *1.50* | *1.50* | ..... |
| 6602 | **4.58** | 6.12 | 10.70 | ..... | 0.93 | ..... | 3.24 | ..... | 4.17 | ..... | 2.28 | 1.25 |
| ..... | *8.00* | *2.00* | *10.00* | *Bn, Super* | *1.00* | ..... | *3.00* | *Animal Matter* | *4.00* | *2.00* | *2.00* | ..... |
| 6820 | ..... | ..... | ..... | ..... | 15.02 | ..... | ..... | ..... | 15.02 | ..... | ..... | ..... |
| 6932 | ..... | ..... | ..... | ..... | 15.13 | ..... | ..... | ..... | 15.13 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... |
| 6611 | ..... | ..... | 9.80 | ..... | ..... | ..... | 3.89 | ..... | 3.89 | 2.19 | 2.19 | 0.90 |
| 6636 | ..... | ..... | 10.30 | ..... | ..... | ..... | 4.05 | ..... | 4.05 | ..... | 2.16 | 2.45 |
| 6758 | ..... | ..... | 9.85 | ..... | ..... | ..... | 3.76 | ..... | 3.76 | ..... | 2.65 | 1.40 |
| 6934 | ..... | ..... | 9.95 | ..... | ..... | ..... | 3.68 | ..... | **3.68** | ..... | 2.19 | 1.12 |
| 7018 | 6.14 | 1.76 | **7.90** | ..... | 1.94 | ..... | 2.11 | ..... | 4.05 | 7.95 | 7.95 | 0.75 |
| 7056 | 6.43 | 4.07 | 10.50 | ..... | ..... | ..... | ..... | ..... | 4.46 | ..... | 2.44 | 1.27 |
| ..... | ..... | ..... | *10.00* | *Bn* | ..... | ..... | *4.00* | ..... | *4.00* | *2.00* | *2.00* | ..... |
| 6633 | ..... | ..... | 20.40 | ..... | ..... | ..... | 3.92 | ..... | 3.92 | ..... | ..... | ..... |
| ..... | ..... | ..... | *20.00* | *Bn* | ..... | ..... | *3.80* | *Animal Matter* | *3.80* | ..... | ..... | ..... |
| 6634 | ..... | ..... | 8.55 | ..... | ..... | ..... | 6.15 | ..... | 6.15 | ..... | 2.37 | 2.85 |
| ..... | ..... | ..... | *8.00* | *Bn* | ..... | ..... | *6.00* | *Animal Matter* | *6.00* | *2.00* | *2.00* | ..... |
| 6635 | ..... | ..... | 8.85 | ..... | ..... | ..... | 4.70 | ..... | 4.70 | 2.29 | 2.29 | 0.95 |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *5.00* | *Animal Matter* | *5.00* | *2.00* | *2.00* | ..... |
| 6647 | ..... | ..... | 34.40 | ..... | ..... | ..... | 0.72 | ..... | 0.72 | ..... | ..... | ..... |
| ..... | ..... | ..... | *33.00* | *Bn* | ..... | ..... | *0.65* | *Animal Matter* | *0.65* | ..... | ..... | ..... |
| 6650 | ..... | ..... | 16.90 | ..... | ..... | ..... | 5.90 | ..... | 5.90 | ..... | ..... | ..... |
| ..... | ..... | ..... | *17.00* | *Bn* | ..... | ..... | *6.00* | *Animal Matter* | *6.00* | ..... | ..... | ..... |
| 6771 | ..... | ..... | 11.60 | ..... | ..... | ..... | 3.99 | ..... | 3.99 | 1.51 | 1.51 | 0.82 |
| ..... | ..... | ..... | *10.00* | *Bn* | ..... | ..... | *4.10* | *Animal Matter* | *4.10* | *1.50* | *1.50* | ..... |

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Western Meat Co.** (*Continued*). **San Francisco, Cal.** | | |
| 7021 | Special | W. D. Richards, Corona | 39.66 |
| | *Guaranteed* | | *39.35* |
| 6819 | Sulfate of Ammonia | B. L. Byer, Upland | 76.61 |
| | *Guaranteed* | | *76.76* |
| 6902 | Sulfate of Ammonia | B. L. Byer, Upland | 77.98 |
| 7058 | Sulfate of Ammonia | A. F. Call Estate, Corona | 78.66 |
| | *Guaranteed* | | *77.90* |
| 6654 | Superphosphate | B. L. Byer, Upland | 16.88 |
| | *Guaranteed* | | *16.92* |
| 6563* | Tankage | H. D. Derwin, Upland | 45.58 |
| 6564* | Tankage | H. D. Derwin, Upland | 46.35 |
| | *Guaranteed* | | *44.50* |
| 6600* | Tankage | J. H. Reynolds, Redlands | 40.19 |
| | *Guaranteed* | | *41.10* |
| 6614* | Tankage | B. L. Byer, Upland | 45.17 |
| | *Guaranteed* | | *42.51* |
| 6617* | Tankage | J. H. Reynolds, Redlands | 45.40 |
| | *Guaranteed* | | *44.68* |
| 6618* | Tankage | J. H. Reynolds, Redlands | 44.80 |
| | *Guaranteed* | | *43.03* |
| 6631* | Tankage | B. L. Byer, Upland | 32.48 |
| | *Guaranteed* | | *32.89* |
| 6632* | Tankage | B. L. Byer, Upland | 47.31 |
| | *Guaranteed* | | *45.65* |
| 6648* | Tankage | B. L. Byer, Upland | 45.83 |
| 6732* | Tankage | E. L. Koethen, Riverside | 45.96 |
| | *Guaranteed* | | *45.19* |
| 6651* | Tankage | B. L. Byer, Upland | 46.36 |
| | *Guaranteed* | | *44.55* |
| 6733* | Tankage | E. L. Koethen, Riverside | 47.39 |
| | *Guaranteed* | | *45.65* |
| 6803* | Tankage | J. H. Reynolds, Redlands | 42.07 |
| | *Guaranteed* | | *43.25* |
| 6804* | Tankage | J. H. Reynolds, Redlands | 42.08 |
| | *Guaranteed* | | *41.19* |
| 6815* | Tankage | B. L. Byer, Upland | 40.41 |
| 6933* | Tankage | Albers Olive Oil Co., Elsinore | **37.99** |
| 6948* | Tankage | W. J. Chauncey, Claremont | 39.63 |
| | *Guaranteed* | | *40.80* |
| 6816* | Tankage | B. L. Byer, Upland | 36.38 |
| | *Guaranteed* | | *37.89* |
| 6817* | Tankage | B. L. Byer, Upland | 48.25 |
| | *Guaranteed* | | *46.22* |
| 6818* | Tankage | B. L. Byer, Upland | 40.82 |
| 6870* | Tankage | Joseph Cleghorn, Highland | 38.21 |
| 6882* | Tankage | William Cleghorn, Highland | 38.12 |
| 6901* | Tankage | F. G. Bush, Ontario | 37.89 |
| | *Guaranteed* | | *37.80* |

*6563—71% fine. *6618—85% fine. *6651—81% fine.
*6564—71% fine. *6631—60% fine. *6733—81% fine.
*6600—73% fine *6632—67% fine. *6803—79% fine
*6614—86% fine. *6648—79% fine. *6804—79% fine.
*6617—80% fine. *6732—78% fine. *6815—66% fine.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | |
| 7021 | 6.16 | 4.54 | 10.70 | ..... | 1.55 | ..... | 5.35 | ..... | 6.90 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.50* | *Bn, Super* | *1.50* | ..... | *5.50* | *Animal Matter* | *7.00* | ..... | ..... | ..... |
| 6819 | ..... | ..... | ..... | ..... | ..... | 20.16 | ..... | ..... | 20.16 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | *20.20* | ..... | ..... | *20.20* | ..... | ..... | ..... |
| 6902 | ..... | ..... | ..... | ..... | ..... | 20.52 | ..... | ..... | 20.52 | ..... | ..... | ..... |
| 7058 | ..... | ..... | ..... | ..... | ..... | 20.70 | ..... | ..... | 20.70 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | *20.50* | ..... | ..... | *20.50* | ..... | ..... | ..... |
| 6654 | 17.96 | 0.34 | 18.30 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | ..... | ..... | *18.00* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 6563 | ..... | ..... | 6.65 | ..... | ..... | ..... | 9.30 | ..... | 9.30 | ..... | ..... | ..... |
| 6564 | ..... | ..... | 7.25 | ..... | ..... | ..... | 9.38 | ..... | 9.38 | ..... | ..... | ..... |
| ..... | ..... | ..... | *7.00* | ..... | ..... | ..... | *9.00* | ..... | *9.00* | ..... | ..... | ..... |
| 6600 | ..... | ..... | 10.40 | ..... | ..... | ..... | 7.48 | ..... | 7.48 | ..... | ..... | ..... |
| ..... | ..... | ..... | *11.25* | ..... | ..... | ..... | *7.55* | ..... | *7.55* | ..... | ..... | ..... |
| 6614 | ..... | ..... | 8.65 | ..... | ..... | ..... | 8.89 | ..... | 8.89 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.50* | ..... | ..... | ..... | *8.31* | ..... | *8.31* | ..... | ..... | ..... |
| 6617 | ..... | ..... | 8.60 | ..... | ..... | ..... | 8.95 | ..... | 8.95 | ..... | ..... | ..... |
| ..... | ..... | ..... | *7.20* | ..... | ..... | ..... | *9.01* | ..... | *9.01* | ..... | ..... | ..... |
| 6618 | ..... | ..... | 9.00 | ..... | ..... | ..... | 8.75 | ..... | 8.75 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.80* | ..... | ..... | ..... | *8.38* | ..... | *8.38* | ..... | ..... | ..... |
| 6631 | ..... | ..... | 16.85 | ..... | ..... | ..... | 4.70 | ..... | **4.70** | ..... | ..... | ..... |
| ..... | ..... | ..... | *14.80* | ..... | ..... | ..... | *5.12* | ..... | *5.12* | ..... | ..... | ..... |
| 6632 | ..... | ..... | 6.05 | ..... | ..... | ..... | 9.79 | ..... | 9.79 | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.50* | ..... | ..... | ..... | *9.50* | ..... | *9.50* | ..... | ..... | ..... |
| 6648 | ..... | ..... | 7.70 | ..... | ..... | ..... | 9.19 | ..... | 9.19 | ..... | ..... | ..... |
| 6732 | ..... | ..... | 7.45 | ..... | ..... | ..... | 9.26 | ..... | 9.26 | ..... | ..... | ..... |
| ..... | ..... | ..... | *7.35* | ..... | ..... | ..... | *9.10* | ..... | *9.10* | ..... | ..... | ..... |
| 6651 | ..... | ..... | 7.20 | ..... | ..... | ..... | 9.39 | ..... | 9.39 | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.50* | ..... | ..... | ..... | *9.25* | ..... | *9.25* | ..... | ..... | ..... |
| 6733 | ..... | ..... | 5.60 | ..... | ..... | ..... | 9.88 | ..... | 9.88 | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.50* | ..... | ..... | ..... | *9.50* | ..... | *9.50* | ..... | ..... | ..... |
| 6803 | ..... | ..... | 11.20 | ..... | ..... | ..... | 7.78 | ..... | 7.78 | ..... | ..... | ..... |
| ..... | ..... | ..... | *11.50* | ..... | ..... | ..... | *8.00* | ..... | *8.00* | ..... | ..... | ..... |
| 6804 | ..... | ..... | 11.40 | ..... | ..... | ..... | 7.75 | ..... | 7.75 | ..... | ..... | ..... |
| ..... | ..... | ..... | *11.70* | ..... | ..... | ..... | *7.50* | ..... | *7.50* | ..... | ..... | ..... |
| 6815 | ..... | ..... | 8.70 | ..... | ..... | ..... | 7.80 | ..... | 7.80 | ..... | ..... | ..... |
| 6933 | ..... | ..... | 7.95 | ..... | ..... | ..... | 7.37 | ..... | **7.37** | ..... | ..... | ..... |
| 6948 | ..... | ..... | 8.90 | ..... | ..... | ..... | 7.59 | ..... | **7.59** | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *8.00* | ..... | *8.00* | ..... | ..... | ..... |
| 6816 | ..... | ..... | 13.25 | ..... | ..... | ..... | 6.16 | ..... | 6.16 | ..... | ..... | ..... |
| ..... | ..... | ..... | *13.39* | ..... | ..... | ..... | *6.48* | ..... | *6.48* | ..... | ..... | ..... |
| 6817 | ..... | ..... | 6.20 | ..... | ..... | ..... | 9.98 | ..... | 9.98 | ..... | ..... | ..... |
| ..... | ..... | ..... | *6.00* | ..... | ..... | ..... | *9.55* | ..... | *9.55* | ..... | ..... | ..... |
| 6818 | ..... | ..... | 9.10 | ..... | ..... | ..... | 7.83 | ..... | 7.83 | ..... | ..... | ..... |
| 6870 | ..... | ..... | 11.40 | ..... | ..... | ..... | 6.87 | ..... | 6.87 | ..... | ..... | ..... |
| 6882 | ..... | ..... | 9.45 | ..... | ..... | ..... | 7.16 | ..... | 7.16 | ..... | ..... | ..... |
| 6901 | ..... | ..... | 10.50 | ..... | ..... | ..... | 6.94 | ..... | 6.94 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | ..... | ..... | ..... | *7.00* | ..... | *7.00* | ..... | ..... | ..... |

*6933—76% fine.
*6948—73% fine.
*6816—82% fine.
*6817—80% fine.
*6818—72% fine.
*6870—70% fine.
*6882—77% fine.
*6901—56% fine.

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Western Meat Co.** (*Continued*). **San Francisco, Cal.** | | |
| 6830* | Tankage | B. L. Byer, Upland | 44.82 |
| | *Guaranteed* | | *46.22* |
| 6871* | Tankage, Diamond I | F. D. Parker, San Fernando | 32.55 |
| 6987* | Tankage, Diamond I | R. H. Gibson, San Fernando | 33.68 |
| | *Guaranteed* | | *33.17* |
| 6878* | Tankage | Benchley Fruit Co., Fullerton | 40.21 |
| | *Guaranteed* | | *40.03* |
| | **Wilson & Co., Successors to Pacific Coast Beef & Provision Co.** | | |
| 6774 | Special Lawn | Geo. Schornick, Los Angeles | 28.81 |
| | *Guaranteed* | | *27.15* |

*6830—66% fine.
*6871—77% fine.
*6987—80% fine.
*6878—78% fine.

| Laboratory No. | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen guaranteed as derived from | Total | From Sulfate | Total | |
| 6830 | ..... | ..... | 10.35 | ..... | ..... | ..... | 8.54 | ..... | **8.54** | ..... | ..... | ..... |
| ..... | ..... | ..... | *6.00* | ..... | ..... | ..... | *9.55* | ..... | *9.55* | ..... | ..... | ..... |
| 6871 | ..... | ..... | 14.75 | ..... | ..... | ..... | 5.05 | ..... | **5.05** | ..... | ..... | ..... |
| 6987 | ..... | ..... | 14.30 | ..... | ..... | ..... | 5.38 | ..... | 5.38 | ..... | ..... | ..... |
| ..... | ..... | ..... | *13.75* | ..... | ..... | ..... | *5.35* | ..... | *5.35* | ..... | ..... | ..... |
| 6878 | ..... | ..... | 10.55 | ..... | ..... | ..... | 7.46 | ..... | 7.46 | ..... | ..... | ..... |
| ..... | ..... | ..... | *11.30* | ..... | ..... | ..... | *7.30* | ..... | *7.30* | ..... | ..... | ..... |
| 6774 | 2.18 | 4.72 | 6.90 | ..... | ..... | ..... | 4.72 | ..... | **4.72** | ..... | 1.83 | 1.67 |
| ..... | *3.50* | ..... | *3.50* | *Bn, Super, T* | ..... | ..... | *5.00* | *Bl, Bn, G, T* | *5.00* | *2.00* | *2.00* | ..... |

## REPORT OF ANALYSIS

Available phosphoric acid is not determined in bone, meal, tankage, and Thomas phosphate powder, unless requested. The fineness of these materials is determined, fine and medium bone being separated by a sieve of 50 meshes to the inch; tankage by a 25-mesh sieve; and Thomas phosphate powder by a 100-mesh sieve.

Nitrogen in ammonium salts will, in some cases, be found reported when nitrogen in this form is not guaranteed. In some of such cases this form of nitrogen is produced by conversion of organic nitrogen during process of manufacture, and is not to be considered a deviation from guaranty of materials used. Guanos carry more or less nitrogen in nitrates and ammonium salts, and when any appreciable quantity of guano is used the manufacturer should take into account the fact that some nitrogen will show as nitrates and ammonium salts. The failure to take this into consideration may account for the appearance of these forms of nitrogen in some samples in which only organic nitrogen was guaranteed.

The percentage of chlorin is given when it exceeds 0.50 per cent. It is a matter of only technical interest whether chlorin present is from muriate of potash, kainit, or from common salt that may be in some of the materials used. If a manufacturer uses sulfate of potash and a tankage with it containing a large amount of chlorin, from a practical standpoint he has changed the quality of his fertilizer just as much as if he had used muriate of potash instead of sulfate of potash. Chlorin from all other sources is as objectionable as from muriate of potash. However, if muriate of potash is found when sulfate is guaranteed, the fact will be published.

The following abbreviations are used in the tables: BatG = bat guano, Bl = blood, Bn = bone, Fs = fish, G = guano, H = hoof, Min. Phos. = mineral phosphate, Super = superphosphates, T = tankage, CSM = cotton seed meal.

Guarantees are entered in italics. Deficiencies greater than allowed by law are entered in bold face type.

Y.R. 30/5

UNIVERSITY OF CALIFORNIA PUBLICATIONS

COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BERKELEY, CALIFORNIA

# POTASH FROM TULE

AND THE

# FERTILIZER VALUE OF CERTAIN MARSH PLANTS

BY

P. L. HIBBARD

BULLETIN No. 288

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BENJAMIN IDE WHEELER, President of the University.

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*Died July 1, 1917.

†In cooperation with office of Public Roads and Rural Engineering, U. S. Department of Agriculture.

# POTASH FROM TULE AND THE FERTILIZER VALUE OF CERTAIN MARSH PLANTS.

By P. L. Hibbard.*

A brief study indicates that 100 to 200 pounds of potash to the acre, worth at present prices, $15.00 to $30.00, may be obtained from a heavy growth of tule, at a cost of perhaps $5.00 to $10.00 per acre. Though this study is not extensive, the facts developed seem of sufficient importance to warrant publication without further delay.

Tule land usually has great agricultural value after it has been reclaimed from its marshy condition. It is thought that much of the expense of reclamation may be defrayed by the value of the potash contained in the marsh vegetation. At the present time any source from which potash may be obtained at reasonable cost is of much interest. Whether a profitable industry of extracting potash from tule can be developed remains to be proved by actual experience on a large scale. The object of this paper is to bring the matter to the attention of those whom it may interest, with the hope that commercial enterprise will demonstrate its possibilities.

## Description, Location and Habits of Tule.

The tule plant (*Scirpus lacustris, var. occidentalis*) is a member of the botanical family of sedges frequently seen growing in the edges of ponds or in marshy places. It is closely related to the common bulrush of the eastern portion of the United States. The plant sends up an annual growth of round, tapering dark green stems, four to ten feet high and one-fourth to one inch thick at the base, tapering to a point at the top which often bears a small bunch of flowers or seeds. With the tule are commonly found other water-loving plants, such as the sedges, grass-like plants of smaller size having a triangular stem; and cattails, often called flags, which have long flat leaves surrounding the base of a tall round stalk at the top of which is a brown cylindrical mass of seed commonly known as cattail. All these and some others grow in quiet, shallow water. Where the water never dries up they are largest. After the water disappears the tule ceases to grow, but many of the sedges and cattails continue to flourish as long as the ground is moist. All produce an annual growth which dies during the winter.

The area of tule land in California is estimated at 500,000 acres. Much of this has been reclaimed but it is thought that there still remains in the delta region of the San Joaquin and Sacramento rivers alone 50,000 acres largely covered with tule. On much of this ground the growth is too sparse or too inaccessible to be of much value. In many other parts of the state are considerable areas of tule land. In overflowed regions the tule is found over broad areas, but is most luxuriant along the edges of sloughs and channels in strips ten to twenty feet wide, where it always has a good supply of water. It grows in both fresh and brackish, but not in salt, water.

The weight of tule on an acre is exceedingly variable. Measurements of small areas in a number of places indicate that the green plants on one square foot weigh one-half to over one pound which would make ten to twenty tons per acre. In drying three-fourths of the weight is lost. The following Table I indicates the source and condition of the plants studied.

*Note.—Grateful acknowledgment is made to Professor J. S. Burd for valuable counsel and suggestions.

TABLE I.

Location, Condition, Etc., of Plants Analyzed.

| No. | Name | Condition of plants | Locality | Water depth, inches | Height of plant, feet | Number stems in sample | Date of sampling |
|---|---|---|---|---|---|---|---|
| 1 | Tule | Fresh | Stockton | 6 | 5-6 | 25 | May 15 |
| 2 | Tule | Fresh | Alvarado | 2-10 | 4-8 | 20 | May 28 |
| 5 | Tule | Fresh | Mallard | 0-6 | 10 | 1 | June 11 |
| 6 | Tule | Fresh | Mallard | 0-6 | 8 | 1 | June 11 |
| 11 | Tule | Fresh | Benicia | 2-6 | 4-7 | 6 | June 11 |
| 15 | Tule | Fresh | Suisun | 2-6 | 5-7 | 3 | June 11 |
| 17 | Tule | Fresh | Newman | ------ | 4-6 | 20 | June 15 |
| 18 | Tule | Fresh | Newman | ------ | 3-4 | 20 | June 15 |
| 20 | Tule | Fresh and 1/10 dead | Middle River | 2-12 | 4-8 | 15 | July 13 |
| 21 | Tule | Fresh | Middle River | 12-24 | 4-8 | 15 | July 13 |
| 23 | Tule | Fresh and 1/10 dead | West Pittsburg | 0-6 | 5-8 | 15 | July 20 |
| 27 | Tule | 1/3 dead | Lisbon | None | 5-7 | 20 | July 26 |
| 30 | Tule | Fresh | Lisbon | 2-12 | 5-8 | 10 | July 26 |
| 28 | Tule and sedge | 1/3 dead | Lisbon | None | 5-7 | 20 | July 26 |
| 24 | Tule, sedge, cattail and weeds | 1/3 dead | Lisbon | None | 4-6 | 25 | July 26 |
| 25 | | | Lisbon | None | 4-6 | 25 | July 26 |
| 26 | | | Lisbon | None | 4-6 | 25 | July 26 |
| 4 | Tule | Dead | Alvarado | 2-10 | 4-8 | 20 | May 28 |
| 9 | Tule | Dead | Mallard | 0-6 | 6 | 5 | June 11 |
| 3 | Sedge | Fresh | Alvarado | 0-2 | 2-3 | 10 | May 28 |
| 10 | Sedge | Fresh | Benicia | 2-6 | 4 | 3 | June 11 |
| 13 | Sedge | Fresh | Suisun | 2-6 | 4-6 | 3 | June 11 |
| 7 | Cattail | Fresh | Mallard | 0-6 | 5 | 1 | June 11 |
| 12 | Cattail | Fresh | Benicia | 2-6 | 5 | 2 | June 11 |
| 14 | Cattail | Fresh | Suisun | 2-6 | 5 | 3 | June 11 |
| 22 | Cattail | Fresh | Bay Point | 2-4 | 3-5 | 10 | July 20 |
| 8 | Cattail | Dead | Mallard | 0-6 | 5 | 1 | June 11 |
| 16 | Cattail | Dead | Suisun | 2-6 | 5 | 2 | June 11 |
| 29 | Fire weeds | Fresh | Lisbon | None | 3-5 | 15 | July 26 |

## Composition of Various Plants.

The composition of the tule plants varies greatly, as is indicated by Table II following. A few analyses indicate that the young plants contain the highest proportion of potash, though the old plants may give a greater yield of potash per acre on account of the larger tonnage. Reasoning by analogy from our definite knowledge of other plants we should reach the same conclusion. This study is not yet sufficiently extensive to prove the theory in regard to tule. However, it is definitely shown that dead plants or those which have been leached by water retain only a small amount of potash.

## Effect of Leaching.

The loss of potash by leaching is shown by the following experiment: A bunch of the stems was soaked in water overnight. The water was poured off and the stems again covered with fresh water to stand another day; this was repeated once more. Finally potash was determined in the different extracts. Of the total potash present before soaking 15 per cent remained in the stems, 58 per cent was in the first leaching, 18 per cent in the second leaching, and 9 per cent in the third leaching. This indicates that a large portion of the potash is not organically combined in the plant, and shows that to obtain much potash the plants must be harvested before rain washes out the valuable salts.

TABLE II.

Percentage—Composition of Plants.

| No. | Name | Condition of plants | Fresh material | | | Water-free material | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Water | Ash | $K_2O$ | Nitrogen | $P_2O_5$ | $K_2O$ | Ash | $K_2O$ in ash |
| 1 | Tule | Fresh | 76.5 | 3.1 | 0.77 | 1.86 | 0.71 | 3.3 | 12.9 | 25.4 |
| 2 | Tule | Fresh | 75.0 | 3.1 | 0.42 | ------ | ------ | 1.7 | 12.2 | 13.8 |
| 5 | Tule | Fresh | 75 est.* | 3.7 | 1.23 | 1.28 | 0.51 | 4.9 | 14.8 | 32.7 |
| 6 | Tule | Fresh | 75 est.* | 3.3 | 0.95 | 1.80 | 0.62 | 3.8 | 13.2 | 28.8 |
| 11 | Tule | Fresh | 75 est.* | 2.8 | 0.80 | ------ | ------ | 3.2 | 11.3 | 28.3 |
| 15 | Tule | Fresh | 75 est.* | 3.0 | 0.75 | 1.19 | 0.41 | 2.9 | 12.1 | 23.2 |
| 17 | Tule | Fresh | 75 est.* | 2.6 | 0.75 | 0.91 | ------ | 2.9 | 10.6 | 26.6 |
| 18 | Tule | Fresh | 75 est.* | 2.7 | 0.80 | ------ | ------ | 3.2 | 10.7 | 30.0 |
| 20 | Tule | Fresh and 1/10 dead | 75.8 | 2.4 | 0.26 | 1.43 | 0.48 | 1.1 | 10.0 | 11.0 |
| 21 | Tule | Fresh | 68.4 | 2.2 | 0.57 | 1.17 | ------ | 1.8 | 6.8 | 26.5 |
| 23 | Tule | Fresh and 1/10 dead | 77.5 | 2.7 | 0.48 | 1.25 | ------ | 2.2 | 11.9 | 18.3 |
| 27 | Tule | 1/3 dead | 58.3 | 3.9 | 0.92 | 0.75 | ------ | 2.2 | 9.4 | 23.4 |
| 30 | Tule | Fresh | 75 est.* | ------ | 0.39 | ------ | ------ | 2.3 | 16.5 | 14.5 |
| 28 | Tule and sedge | 1/3 dead | 52.0 | 4.8 | 1.01 | ------ | ------ | 2.1 | 10.1 | 20.8 |
| 24 | Tule, sedge, cattail and weeds | 1/3 dead | 54.4 | 4.7 | 1.00 | ------ | ------ | 2.2 | 10.3 | 21.3 |
| 25 | | | 54.4 | 4.3 | 1.05 | ------ | ------ | 2.3 | 9.4 | 24.4 |
| 26 | | | 60.0 | 3.2 | 0.76 | 0.70 | 0.40 | 1.9 | 8.1 | 23.4 |
| 4 | Tule | Dead | 63.1 | 3.7 | 0.99 | ------ | ------ | 2.7 | 10.1 | 25.8 |
| 9 | Tule | Dead | 50 est.* | 6.6 | 0.05 | 0.78 | 0.15 | 0.1 | 13.3 | 0.8 |
| 3 | Sedge | Fresh | 85.9 | 1.8 | 0.52 | 1.86 | 0.54 | 3.9 | 13.0 | 30.0 |
| 10 | Sedge | Fresh | 85 est.* | 3.0 | 0.45 | 2.02 | 0.51 | 3.0 | 19.8 | 15.2 |
| 13 | Sedge | Fresh | 85 est.* | 2.3 | 0.63 | 1.95 | 0.51 | 4.2 | 15.6 | 27.0 |
| 7 | Cattail | Fresh | 75 est.* | 2.9 | 0.87 | 1.55 | 0.52 | 3.5 | 11.8 | 30.0 |
| 12 | Cattail | Fresh | 75 est.* | 3.6 | 0.57 | ------ | ------ | 2.3 | 14.5 | 16.5 |
| 14 | Cattail | Fresh | 75 est.* | 2.8 | 0.88 | ------ | ------ | 3.5 | 11.0 | 31.7 |
| 22 | Cattail | Fresh | 72.2 | 2.0 | 0.31 | 0.95 | 0.48 | 1.1 | 7.0 | 14.9 |
| 8 | Cattail | Dead | 50 est.* | 3.8 | 0.60 | 0.94 | 0.52 | 1.2 | 7.5 | 16.0 |
| 16 | Cattail | Dead | 50 est.* | 3.1 | 0.15 | 0.53 | 0.32 | 0.3 | 6.2 | 4.8 |
| 29 | Fire weeds | Nearly fresh | 62.5 | 2.1 | 0.64 | 0.71 | 0.31 | 1.7 | 5.5 | 30.9 |

*Est. indicates that amount of water was estimated, not actually determined.

The amount of potash in tule ash is also quite variable, as will be seen by a study of Table II. It seems probable that plants growing in a scanty supply of water or in saline water carry a larger proportion of potash in the ash.

## Composition of Tule Ash.

This has been only slightly studied. A proximate analysis of the ash is given in Table III. From this it seems that the potash in the tule is largely present in mineral condition and not organically combined as in most land plants. In this respect it resembles the kelps of the ocean. This ash was obtained by burning several pounds of sample No. 2 on an iron plate in open air. It was separated by leaching with water into the insoluble and the water-soluble portions.

TABLE III.

| | | |
|---|---|---|
| The total ash contained: | | |
| Unburnt carbon | 14.4 per cent | |
| Water insoluble mineral matter | 40.3 per cent | |
| Water soluble salts | 45.3 per cent | |
| | | 100.00 per cent |
| The water soluble salts consisted of: | | |
| $Na_2O$ | 8.0 per cent | |
| $K_2O$ | 16.8 per cent | |
| Cl | 14.4 per cent | |
| $SO_3$ | 4.7 per cent | |
| $CO_2$ | 1.4 per cent | |
| | | 45.3 per cent |

The water-insoluble mineral matter consisted of sand, clay, iron oxid, etc., with a little lime and magnesia.

## Harvesting the Tule.

As above indicated the tule should be harvested before the leaching action of rain begins, probably best during September or sooner.

The crop may be cut with an ordinary mowing machine if the ground is dry enough to bear a team. After it has dried somewhat it may be raked into piles and carried to a smooth spot of hard ground from which the ashes may be easily shoveled up after the tule is burned. It will not be necessary to wait till it is very dry to burn it as after the fire is once started it will furnish heat enough to keep burning comparatively green material. This is desirable in order to avoid a very high temperature which would be liable to cause loss of potash.

The quantity of dry material and amount of potash per acre with other conditions are indicated in Table IV.

The rankest growth of tule is found along the edges of streams and swamps where there is always more or less water, so that it will never be possible to harvest it by means of an ordinary mowing machine. It is not probable that hand-cutting will pay. A machine something like a grain harvester mounted on a scow would probably be able to cut the tule cheaply (and convey it to a spot where it could be dried and burned). The whole operation must be well planned and worked out so as to handle the crop very inexpensively because the value of the product is not great enough to bear any costly method of harvesting.

TABLE IV.

Yield of Air-Dry Material and Potash.

| No. | Name | Location | Per cent potash | | Yield per acre (lbs.) | | Depth of water on ground |
|---|---|---|---|---|---|---|---|
| | | | In air-dry material | In ash | Air-dry material | Potash | |
| 20 | Tule | Middle River | 1.0 | 11.0 | 18,000 | 171 | 1 ft. |
| 21 | Tule and 10% cattail | Middle River | 1.6 | 26.5 | 12,000 | 212 | 2 ft. |
| 23 | Tule | West Pittsburg | 2.0 | 18.3 | 13,000 | 254 | ½ ft. |
| 27 | Tule | Lisbon | 2.0 | 23.4 | 6,000 | 102 | None |
| 28 | Tule and sedge | Lisbon | 1.9 | 20.8 | 7,000 | 134 | None |
| 22 | Cattail | Bay Point | 1.0 | 14.9 | 15,000 | 157 | ½ ft. |
| 24 | Tule, sedge, cattail, weeds | Lisbon | 2.0 | 21.3 | 4,000 | 87 | None |
| 25 | | Lisbon | 2.1 | 24.4 | 4,000 | 87 | None |
| 26 | | Lisbon | 1.7 | 23.4 | 5,000 | 86 | None |

## Extraction of Potash From the Ash.

It is shown above that much of the potash may be extracted from tule by leaching, but in general it will be simpler to burn it first. The dry hay burns easily. All that is necessary is to get it onto ground where the ash can be easily recovered, and to avoid high temperatures which would cause loss of potash. After burning, it will probably be desirable to moisten the ash which is very light, in order to prevent loss by blowing. The ash may be used directly as a potash fertilizer or it may be leached with water to make high-grade potash salts. If the water is made to percolate slowly through the ash, the first runnings, in volume about equal to the volume of the ash, will contain most of the potash. Fresh water will then extract more of the potash. The weak extract thus obtained should be used instead of fresh water to extract new ash. In

this way most of the potash will be obtained with a minimum amount of water which must be evaporated to obtain the potash salts. The first crystallization of salts from the leachings is largely composed of potassium chloride and surlate, containing nearly 50 per cent $K_2O$. Further evaporation and crystallization yields a product containing less potash. The process should be similar to that used in obtaining potash from wood ashes.

In order to manufacture high-grade potash salts from tule a considerable plant and experienced management will probably be required, therefore such manufacture is not here advocated. The present object is rather to indicate the possibility of obtaining at small expense, by inexperienced persons, tule ash containing potash in a form which may be used as a fertilizer and in some measure help to pay the cost of recovery of the land.

### Comparison of Tule With Other Sources of Potash.

Crude tule ash contains 7 to 15 per cent $K^2O$, which is more than most wood ashes contain. The tule ash here meant is the crude ash containing much carbon and soil, not the pure ash given in Table II. The percentage of crude ash is considerably greater than of the pure ash. Unlike wood ashes, in which most of the potash is present as carbonate there is but little of this form in tule ash. In this particular it is quite similar to kelp ash, which contains most of its potash as chloride. In other respects it is not similar to kelp ash.

The available potash in tule ash is similar to that of carnallite from the Stassfurt mines, which contains about 10 per cent of $K_2O$, chiefly in the form of chloride. Part of the tule potash is in the form of sulfate. The tule ash should be preferable to carnallite or kainit as a fertilizer because it contains less of the other undesirable chlorides. Like the other sources of potash above mentioned, tule ash is not suitable for mixing with other materials to make high-grade fertilizers because the large amount of inert material in it would lower the grade of the complete fertilizer. The high-grade potash salts obtained by extracting tule ash would be suitable for high-grade fertilizers.

### Fertilizer Value of Tule.

Reference to Table V will show that tule has considerable value as a source of plant food. If plowed under it will probably decay readily, thus liberating its plant food and at the same time furnishing valuable humus which is commonly needed in California soils. As a source of plant food the fresh tule compares well with barnyard manure and other waste materials, such as straw or leaves. Like these it is not valuable enough to bear high cost of transportation, so that it must be used near where it grows. However, tule land itself is not likely to be benefited by the addition of tule as a fertilizer.

TABLE V.

Plant Food in Various Species of Marsh Growth.

(Pounds in one ton of fresh material.)

| No. | Name | Nitrogen | $P_2O_5$ | $K_2O$ |
|---|---|---|---|---|
| 1 | Tule | 9.2 | 3.6 | 15.4 |
| 5 | Tule | 6.4 | 2.6 | 23.6 |
| 6 | Tule | 9.0 | 3.1 | 19.6 |
| 15 | Tule | 6.9 | 2.6 | 14.5 |
| 9 | Tule, dead | 7.6 | 1.5 | 1.6 |
| 7 | Cattail | 7.8 | 2.6 | 17.5 |
| 22 | Cattail | 5.3 | 2.8 | 6.2 |
| 16 | Cattail, dead | 5.3 | 3.2 | 3.9 |
| 3 | Sedge | 5.2 | 1.5 | 10.6 |
| 10 | Sedge | 6.0 | 1.4 | 5.0 |
| 13 | Sedge | 5.8 | 1.4 | 12.6 |

As a fertilizer material the tule has some resemblance to the potash-bearing kelps of the Pacific Coast.

Fresh kelp (*Macrocystis pyrifera*), according to Burd*, contains in 1 ton about 4 pounds of nitrogen, 2 pounds phosphoric acid and 36 pounds of potash. Fresh tule contains about 6 pounds of nitrogen, 2 pounds phosphoric acid, 12 pounds of potash. Barnyard manure contains about 2 pounds of nitrogen, 2 pounds phosphoric acid and 4 pounds of potash per ton. All of these figures vary considerably with season, locality and treatment of the particular material. The tule has a considerable advantage over kelp in that it readily dries and may be burnt to an ash which has commercial value as a source of potash, while kelp is not easily dried and burnt.

While recovery of potash from tule may not be commercially profitable as such, where there is no intention to utilize the land, it is quite possible that this source of income may permit the recovery of lands which could not otherwise be reclaimed economically.

## Summary.

1. California marsh vegetation, particularly tule, contains potash which may be somewhat easily obtained and thus help to pay cost of reclaiming the land.
2. Tule growth along sloughs, etc., contains potash worth recovering for its own sake.
3. Tule may be cut by a mowing machine and easily dried and burnt to obtain the ash.
4. The potash is recovered in the ash by burning the dry plants.
5. The ash may be used directly as a potash fertilizer or from it may be extracted high-grade potash salts by simple, inexpensive methods.
6. The ash is similar to kainit as a source of potash.
7. Dead or leached plants have lost most of their potash.
8. The tule plant has a fertilizer value comparable to that of barnyard manure or Pacific coast kelps.
9. Potash recovery from tule may never become a source of great wealth, but it may be of considerable local importance as a source of potash at times such as the present when potash is very scarce and costly.

*Bulletin 248, page 204, of this station.

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# THE USE OF LUMBER ON CALIFORNIA FARMS

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**BULLETIN No. 299**
SEPTEMBER, 1918

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No.

# THE USE OF LUMBER ON CALIFORNIA FARMS

By MERRITT B. PRATT

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This circular aims to give the farmers of California information regarding the properties of different woods available in the state, and the relation of these properties to different uses made of lumber on the farm. It is introductory to plans for farm structures prepared by the Division of Agricultural Engineering, University Farm, Davis, California. These plans, which can be borrowed without charge by any farmer in California by writing to the Division of Agricultural Extension of the University of California, are designed to meet the demands made for farm buildings in this state.

## CONSIDERATIONS IN PLANNING FARM STRUCTURES[1]

*Low Initial Cost.*—The first object sought in any farm structure, whether it be a house, barn, silo or hog-pen, is to provide in a suitable manner for all purposes necessitating its erection. In most constructions, however, a wide variation in costs is possible, ranging from a too low first cost, which results in unsatisfactory construction, to an unduly high cost, which places too great a tax on the farm business for the use of the structure.

In every structure it is well to keep the first cost as low as consistent with proper construction, bearing in mind that the first cost of a structure influences to some extent the resulting upkeep cost. That is, a well-built structure may amount to relatively more in original cost than a poorly constructed one, but the greater cost may be justified in view of subsequent reduced upkeep cost.

Structures are not in themselves direct producers of income but rather contribute as aids to production. The less the expenditure involved in structures, the smaller are the charges to be met by the business.

For the use of structures the farm must pay for upkeep—repairs, replacement and protection—and the overhead charges of interest on all money spent upon the structure. As these charges must be met by the sale of products, the lower the charges the better do the structures meet the need for which they were erected.

Suppose a farmer plans the erection of certain buildings, and two kinds of structures are possible, one costing $1200 and the other $5000. Assuming the more costly is longer lived, the detailed annual charges which the farm must meet for the use of these buildings will be about as follows:

6 per cent interest on the money invested.
4 per cent of original cost for repairs of the $1200 buildings.
3 per cent of original cost for repairs of the $5000 buildings.
3 per cent of original cost for depreciation of the $1200 buildings.
2 per cent of original cost for depreciation of the $5000 buildings.

This means a total annual charge for the use of the buildings of:
$124 for structures costing $1200.
$393 for structures costing $5000.

[1] Prepared by Richard L. Adams of the Division of Agronomy. Photos 1, 2, 3, 4, and 5 by Professor R. L. Adams.

If the size of the ranch is 40 acres, each acre will be called upon to bear its pro rata of the annual charge to the extent of:

$3.10 for the $1200 buildings, as against
$9.82 for the $5000 buildings.

*Low Upkeep Cost.*—The amount of painting, replacement, and repairs varies with different structures, and constitutes an annual upkeep factor to be borne in mind in planning structures. It is desirable to determine which factor shall rule: a low original cost with resulting high annual upkeep cost; or the reverse, a relatively high original cost with a correspondingly low annual charge for maintenance. In every instance, upkeep cost should be as low as is consistent with the original cost and use of a structure.

*Factors Determining Type of Construction.*—The type of construction is determined by the nature of the use to which the structure is to be put and the local climatic condition.

A horse barn, for instance, must combine qualities different from those demanded of a warehouse for the storage of grain. The latter must not include to any extent ventilation, freedom from drafts, sanitary convenience, comfort or warmth—qualities very necessary in a structure designed for the protection of stock. A plan for a ditch structure must consider stability, permanency, water tightness, safety and low initial cost. Ditch structures for sandy land should be of somewhat different construction from those in heavy clay soil due to the greater liability of erosion and seepage.

A portable field shelter for stock will necessitate light construction to permit moving it from place to place. Hay barns will vary in the degree of stability to be provided, depending on whether the hay is to be stored on the ground or in an overhead mow, and on the exposure to wind. Bridges for use of tractors demand heavier construction than for small team loads. The man whose dairy is to be permanent will usually favor a more substantial silo than he who is embarking in dairying as an experiment and may later conclude to eliminate cows.

As to the difference in construction necessitated by climatic conditions, one need only compare the widely different conditions for stock protection to be met, for instance, in Humboldt County, having an annual mean rainfall of 38 inches, 128 rainy days, 88 clear days, and temperatures rising and falling between 30° and 74°, with the Imperial Valley with less than 3 inches of rainfall, 11 rainy days, 312 days of sunshine annually, and temperatures of from 25° to 114° F. The kind of protection to be provided against the cold and wet of the rainy season and the heat of the dry season varies greatly in the two

sections, while the life of building materials will not be the same under two such widely different environments.

## ADAPTABILITY OF WOOD FOR FARM USE

When the type of farm structure suitable for the demands to be made upon it is determined, there follows a consideration of the materials for its construction.

Under California conditions wood is the favorite farm building material because of its suitability, reasonable cost and availability. Moreover, the working up of lumber is best understood by the average man, the left-overs can be utilized for odd jobs or for fire wood, while second-hand material has a substantial value for many purposes around the farm.

All factors considered, the farmer finds wood the best all-around material for the majority of farm uses, and therefore it is important that he should know something of the various woods available, their suitability for farm uses, and how to buy intelligently for a definite purpose.

### SUITABILITY OF WOOD

*Not all Woods Have the Same Properties.*—In general, wood is strong relative to its weight, readily shaped with tools, light and easy to handle, readily secured, and economically transported as compared to other materials, but in particular some woods possess properties such as durability, strength and stiffness to a greater degree than others, which fit them for specific uses. For example, Douglas fir is unexcelled where strength is the main factor, and redwood where durability is required. If Douglas fir were used for irrigation boxes, however, and redwood for heavy bridge timbers, it is probable that both woods would prove unsatisfactory because of the failure to put them to the use for which they were best suited.

The diversified climatic conditions of California call for considerable discretion in the choice of species. Lumber exposed to the sun in hot, dry sections tends to warp and check. A soft wood such as redwood, western yellow pine or sugar pine is more suitable in such cases than a harder wood like Douglas fir, which tends to check when exposed to the direct rays of the sun. Hemlock and white fir are satisfactory in a hot section if thoroughly dried, but if green, are most unsatisfactory. In all climates durable woods should be used whenever the lumber comes in contact with the ground, or is used in a damp or wet location.

As a guide in the selection of the right wood for a particular use, there is given later (p. 108) an account of the properties of the woods most available to the California farmer.

*Some Cases where Wood is Preferable.*—Wood is often wrongly displaced on the farm for uses for which it is better adapted than any other material. Horse corrals are often fenced with barbed wire, and as a result, stock are frequently injured by running against it when frightened. Floors in horse stalls should always have a wood covering, even if there is a concrete base, for the sake of warmth and prevention of injury to the feet of stock through stamping. Wooden

Fig. 1.—Attractive buildings are an asset to any farm. The California farmer has his choice of a variety of woods which embrace all the structural requirements for attractive and serviceable farm building.

pipe is often better than any other material for ditch structures, especially where there is a likelihood that there will be an expansion of the ditch system in the future. In that case the wooden structure could be much more easily and cheaply altered than if built of concrete.

Recent experiments by the Iowa Agricultural Experiment Station[2] with hog houses made of wood and metal showed that the range of temperature was nearly 75 per cent greater in the metal house which was much hotter at noon and cooler at night. The increased range

[2] Bulletin 152, Iowa Agricultural Experiment Station.

of temperature in the metal houses makes it evident that they are less desirable than wooden structures as far as the conditioning of the stock is concerned.

*Knowledge of Lumber Grades Important.*—The best and safest use of wood comes from a knowledge of not only the kinds but the grades of lumber in relation to the use which is to be made of it. The farmer who bought lumber at $30 per thousand to cover his hay stack, could probably have secured the same protection had he purchased a cheaper grade of boards at $25 per thousand. On the other hand, he would have made a mistake had he used the cheap grade of boards

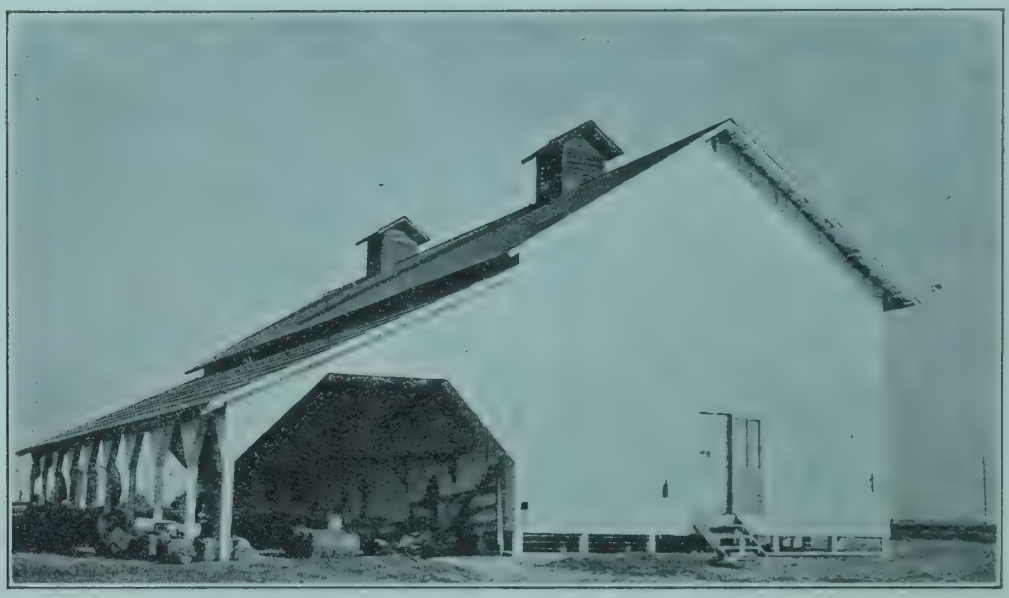


Fig. 2.—An implement shed, even under California conditions, well warrants the expenditure for lumber by lengthening the life of farm implements.

for his corral fence which requires material free from serious defects to withstand the sudden shocks to which it is frequently subjected. In these instances, an idea of lumber grades would have prompted a better selection of material for the use.

*Basis of Lumber Grades.*—Lumber is separated into various grades to make it suitable for different classes of consumers, and to enable manufacturers to maintain a uniformity of production. Grades are determined by the number, size and location of defects as is shown in the table of grades given for Douglas fir and redwood on page 98. Lumber with practically no defects is of the highest grade and is the most valuable, while lumber which has many defects is of poor quality and brings a relatively lower price.

The following defects are those chiefly recognized in the grading of lumber: (1) *Knots.* These are classified according to their form, size, soundness and the firmness with which they are held in place. (2) *Pitch pockets.* The number and size of the pitch pockets, which are openings between adjacent layers of growth containing more or less pitch, is an important consideration in fixing the grade of Douglas fir and western yellow pine lumber, which contains more or less pitch. (3) *Shake.* A separation of the growth layers of the tree presumably due to the swaying action of the wind, causes shake, which seriously reduces the quality of the wood when converted into structural

Fig. 3.—Lumber enters largely into the equipment of California poultry plants.

materials. (4) *Stain.* Blue stain, which is commonly found in pine lumber, is caused by certain low forms of plant life called fungi, the activity of which produces discoloration in the sapwood. It does not injure the strength of the wood, but is considered a defect because it detracts from the bright, clean appearance of the board. (5) *Rot.* Certain fungi attack the wood substance and break down the structure until the wood becomes rotten. In Douglas fir, rot is indicated by a decided softness of the wood where it is discolored, or by small white spots resembling pin worm holes.

*Relation of Grade to Use.*—Lumber is used either in its entirety or is resawed into new sizes. The greater part falls into the first

class, as dimension, which is used for studding, joists, sills, and rafters; and boards, which are used for siding, sheathing, partitions and other construction purposes. Both of these classes of material use lumber in the form and size in which it was first manufactured. Lumber included in the second class embraces the cutting grades which find their largest use in factories where they are sawed into sash and door stock, interior finish and box shook.

## REASONABLE COST OF LUMBER

*How Lumber is Generally Sold.*—Lumber is generally quoted by dealers in terms per thousand feet board measure, the common abbreviation for 1000 feet board measure being "M" ft. B. M. The unit by which lumber is reckoned is the board foot, which is a square foot one inch thick. Lumber less than one inch thick is figured as if one inch.

To obtain the number of board feet in a piece of lumber, multiply together the thickness and width in inches, divide the product by 12 and multiply the result by the length in feet.

*Examples:*

| Pieces | Size | Length | Contents in board feet |
|---|---|---|---|
| 1 | 2 × 8 | 30 | 40 |
| 1 | 4 × 10 | 18 | 60 |
| 1 | 10 × 10 | 36 | 300 |

*Average Mill Prices.*—Statistics show that lumber prices based on the figure obtained by the manufacturer over the entire country were 10 per cent less in 1915 than in 1906, an actual loss in the period which has marked an average increase of 33 per cent in the price of other commodities. In 1906, fifty bushels of wheat would purchase 1,200 feet of No. 1 sheathing, while in 1916 the same amount of wheat would purchase 2,800 feet of the same material. A comparison of the prices of different kinds of building materials from 1912 to 1916 shows an advance of 32.6 per cent for Portland cement, 17.3 per cent for brick and 63.5 per cent for steel, while the price of lumber advanced only 0.6 per cent during this period for all classes of consumers.

*Retail Prices.*—The average price obtained by country dealers is from $2.50 to $4 more per thousand feet than that received by city dealers. This is partially due to the higher cost of merchandising and distribution of small amounts of lumber. The higher average

price in country yards is also influenced by the better quality of stock demanded by the farmer, and the higher gross profits made by the country dealer due to lack of competition.

Figures obtained in a recent study made by the U. S. Forest Service[3] showed that farmers in the middle West paid an average price of $31–$32 per thousand feet for lumber in the period from 1912 to 1915. This figure is probably somewhat high for California, especially in the interior valleys, because of the ready accessibility of a variety of woods, and the number of competing yards.

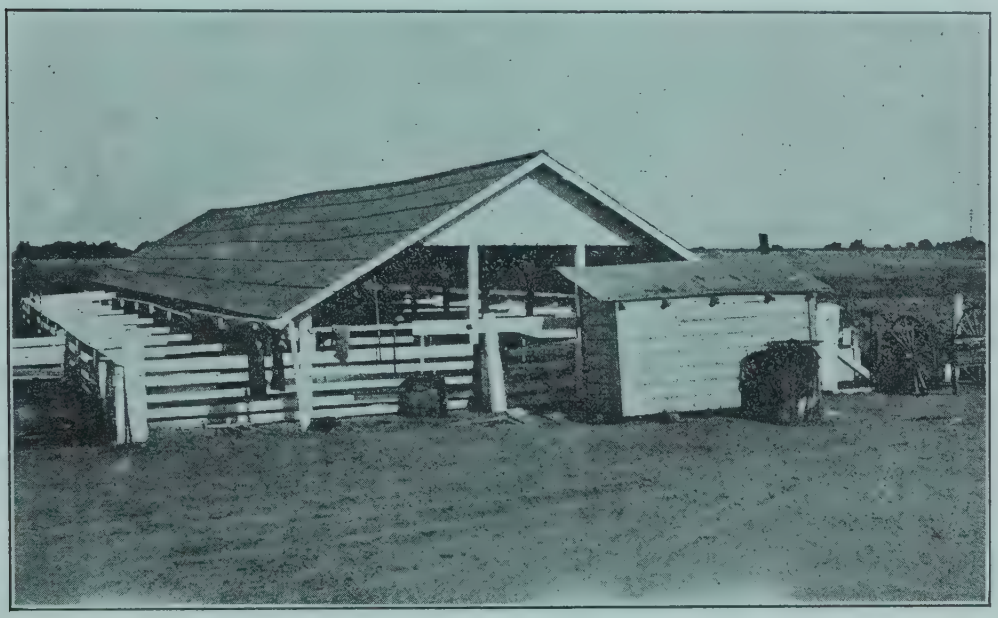


Fig. 4.—Lumber is the prevailing material used in the construction of swine-farrowing pens.

In considering retail prices, the effect of quality should be kept in mind. For finish, flooring, tank stock and other uses where the upper grades are necessary, the cost is high in comparison with the lower grades because of the choice qualities of the lumber which fit it for special purposes.

The relation of grade and price is shown in the following tabulations which give the basis for some of the principal grades made for Douglas fir and redwood, and the influence which quality exerts on price. The range given is that which existed in yards in the Sacramento Valley in January, 1917.

[3] Report No. 114, U. S. Dept. of Agriculture, Some Public and Economic Aspects of the Lumber Industry.

| Grades | Basis of grades | Approximate difference in prices per M between grades |
|---|---|---|
| *Douglas Fir—* | | |
| No. 1 vertical grain flooring, 3, 4 and 6 inch | Each piece must have perfect edges and be free from defects. Angle of grain must not be less than 45 degrees | |
| No. 2 vertical grain flooring, 3, 4 and 6 inch | Admits of a few, small close pitch pockets, or equivalent defects | $5 cheaper than preceding grade |
| No. 2 and better flat grain flooring, 3, 4 and 6 inch | Flat grain. Admits of slight defects such as small knots and pitch pockets | $5 cheaper than preceding grade |
| No. 3 clear flooring, siding and rustic | Admits of considerable defect such as checks, knots and pitch pockets | $2.50 cheaper than preceding grade |
| Timbers, 4 × 4 and larger | Must be well manufactured and free from checks and knots which will weaken the piece | $5 cheaper than preceding grade |
| No. 1 dimension, 2 × 4, 2 × 6, etc. | Must be suitable and of sufficient strength for all ordinary construction purposes without waste. | $2 cheaper than preceding grade |
| No. 1 common boards and shiplap, 4 to 12 | Must be firm and sound and suitable for use in ordinary construction | Price about the same as above |
| No. 2 dimension and common | Admits of unsound knots, rotten streaks and other defects. Suitable for cheap and temporary construction. | $3 cheaper than preceding grade |
| *Redwood—* | | |
| Clear | Practically free from defects. Sap must not exceed 4% of area of all surfaces | |
| Sap clear | Can contain sap in excess of 4% of the area of the surfaces | $2 cheaper than preceding grade |
| Standard | Allows 3–4 sound knots 1¼ inch in diameter or 1–2 sound knots between 1¼–2 inches in diameter | $3 cheaper than preceding grade |
| Extra merchantable | Sound lumber free from defects which will impair its usefulness. Allows 10% sap on all surfaces | $6 cheaper than preceding grade |
| Merchantable | 60% extra merchantable and not to exceed 40% construction | $3 cheaper than preceding grade |
| Construction | Allows knots, sap, shake, and other defects that do not impair the strength of the piece | $3 cheaper than preceding grade |
| No. 3 common | Admits defects that render it unfit for substantial construction work | $3 cheaper than preceding |

*Hints on Buying Lumber.*—It is often more satisfactory for the purchaser of lumber to know the price per piece or per foot than the price per thousand feet. To the average man there is a cloud of mystery surrounding the purchase of a bill of lumber which can be dispelled if he buys it as he would any other commodity. If he knows that a 1 × 12 16-foot stick costs 52 cents, 200 feet of flooring can be secured at 3.2 cents per foot, he has definite prices for definite articles which might not be so well comprehended if the price were given as $32.50 per thousand feet board measure. The prices do not sound as big to the purchaser who feels more at home in figuring the

Fig. 5.—A new type of California bunk-house, 24′ × 54′, with 6-foot porch attached.

cost of a barn or shed. Also he can check his purchase without a lot of figuring, which is a degree of satisfaction. For these reasons, lumber dealers are getting more and more into the habit of selling small lots by the piece or board foot.

In purchasing lumber it is always a good plan to tell the dealer what it is to be used for. His experience should be of assistance in the proper selection of the species, size and grade of lumber best adapted for the desired needs. He will be glad to draw up plans and make out a bill of lumber for the barn or shed which is contemplated. Lumber dealers want their customers to come again. It is not to their interest to allow customers to buy timber which quickly decays for

use in moist places, or to advise too high grade or too expensive wood for protected interior situations.

There is often a tendency on the part of the farmer to use a better grade, or at least a better quality, of lumber than he actually needs. For example, it is because of the large demand for 1 × 12 boards that the cost of this size is about $4.00 per thousand higher than narrow stock such as 1 × 8, which would probably serve the purpose just as well.

This rule also applies to the length of the piece since the value of a board increases with its length as well as its width. It is a distinct loss to buy a board 16 feet long and 12 inches wide to saw into pieces 8 feet long and 6 inches wide. Short, narrow lumber is available in all retail yards, and in buying it the farmer will not only save money but also secure a better grade of lumber for the purposes he has in mind.

In many lumber yards there is a "bone pile" which is the resposi-tory of broken, warped, checked, rotten, stained and odd pieces of lumber of all kinds. Much of this material is worthless, but consider-able good lumber can be secured by the trouble of picking over the pile. Many short pieces can be secured from broken boards, and warped pieces can be cut into shorter lengths so as to utilize much of the material. Weathered boards which have been discolored by exposed to the rain and sun are often discarded because of their appearance. These boards, as well as those affected with blue stain, have not been impaired in strength, and can be readily used about the farm. Another class of material which can be used to advantage for "tinkering" purposes is the short pieces which have been used as car stakes and straps.

One lumber yard in the San Joaquin Valley utilizes much of the defective material which otherwise would go into the "bone pile" by making it up into ready-made articles such as the farmer needs (see Fig. 6). A portable feed rack is made out of lumber for which the company could not get more than $10–$12 per thousand, and the price obtained for it raises the price received for the lumber to a considerable degree. Other articles made out of this low grade lumber are 6 × 8 hog houses, sections of fencing to go around the hog houses and feed troughs. In the last named article the material for making the trough proper has to be of good material, but the rest of the stock can be of very low grade. The example set by this lumber company should be a pointer to every farmer in his purchase of lumber.

## AVAILABILITY OF LUMBER

*Softwoods and Hardwoods.*—The California farmer has his choice of a wide variety of woods, the greater part being cut from Pacific Coast conifers; cone-bearing trees, with needle or scale-like leaves, such as pine, fir and redwood. The wood produced by conifers is known to lumbermen as "softwood" to distinguish it from that pro-

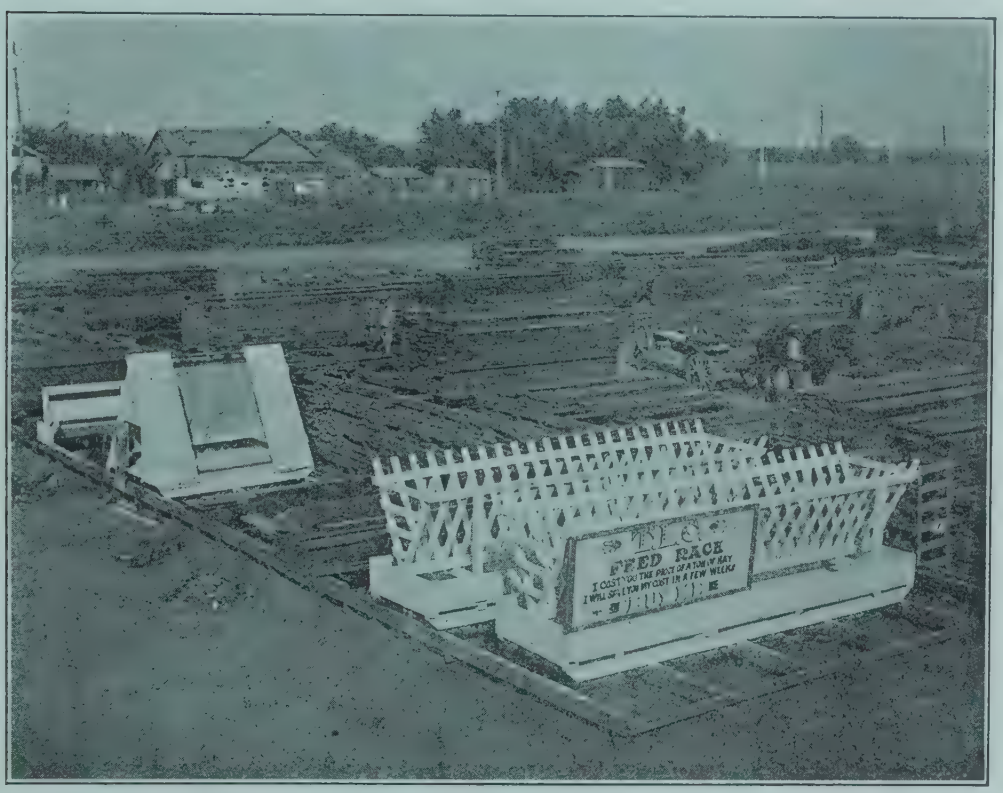



Fig. 6.—Low-grade material is sometimes utilized by retailers to make feed-racks, farrowing pens and other articles needed on the farm.

duced by broad-leaved trees such as oak, hickory and ash, which is called "hardwood." These terms are somewhat inexact since some so-called softwoods like Douglas fir and western yellow pine are harder than some so-called hardwoods such as basswood and willow. In comparison with the wealth of softwood timber in the Pacific coast forests, the supply of hardwoods is very meagre and inferior in quality. A few kinds have some use on the farm, but as a general rule the hardwood material used grows in the eastern states.

## THE STRUCTURE OF WOOD

*Sapwood and Heartwood.*—Wood is made up of very small cells of various sizes and form, more or less closely packed together. These cells are divided into two distinct regions in every tree, called the sapwood and heartwood. The sapwood is the layer of wood on the outer circumference of the tree just under the bark and is generally light in color. The heartwood, which occurs around the pith at the center of the tree, is conspicuous from the sapwood in some woods as red cedar and redwood, because of its darker color. Heartwood is much more durable than sapwood in its natural state, but sapwood can be treated with preservative much more readily.

*Annual Rings.*—Trees in temperate climates normally add each year a layer of wood which is known as an annual ring. These rings are more marked in trees growing where there are well defined seasons. In eucalyptus, which has no well defined growing season, they are rather indefinite.

Three kinds of sections can be cut in respect to the annual rings.

1. A cross or transverse section is taken at right angles to the height of the tree. It shows the annual layers of growth and the size and arrangement of the cells better than any outer surface. (See Figs. 8, 9, and 10.)

2. A radial section is secured when wood is cut along a longitudinal plane passing through the center of the tree. By "quarter-sawing" is meant sawing along the radius. Lumber cut in this way has what is known as "vertical" grain and makes high-grade flooring because of its wearing qualities.

3. A tangential section results when wood is cut tangent to the annual rings, producing what is known as flat or "slash-grained" lumber. The figure of the wood is brought out to the best advantage by reason of the appearance of the annual rings.

*Spring and Summerwood.*—Each annual ring is made up of an inner, softer, light colored part formed early in the season which is known as the springwood and an outer, firmer, dark-colored portion which is formed later and which is known as the summerwood. Springwood cells are usually larger in diameter than those formed later in the year.

*Medullary Rays.*—Besides the wood cells whose length is parallel to the stem, there are other cells which run at right angles to it. In cross-section, these cells, which make up what are known as the medullary rays, appear as whitish lines extending from the pith to the

circumference like the spokes in a wheel. Medullary rays are found in all kinds of trees, but are most conspicuous in such hardwoods as oak and beech where they produce the so-called "silver grain." (See Fig. 9.)

## PROPERTIES AND FARM USES OF WESTERN SOFTWOODS

### DOUGLAS FIR ("OREGON PINE")

*Relation of Strength to Use.*—Douglas fir embodies the requisites for a good building wood, inasmuch as it has strength, stiffness, medium weight and is easy to handle and work. Because of these

Fig. 7.—Specimens of Southern yellow pine showing relation of density to strength. The section on the left is from a timber having 52 per cent of summerwood and a breaking strength of 11,705 lbs. per square inch. The timber from which the other section was taken had 18 per cent of summerwood and a breaking strength of 7393 lbs. per square inch. (Tests made by U. S. Forest Products Laboratory, Madison, Wis.)

qualities, and especially its strength, which is not exceeded by any wood of its weight in this country, it is the chief wood used on the Pacific coast for structural purposes. Douglas fir is manufactured into all forms of dimension stock and meets the requirements for supporting columns, girders, beams and floors of large buildings of warehouse character, and for joists, studding, rafters, supports and framing lumber of all kinds for houses, barns and other smaller building construction.

The strength of a timber increases in a uniform manner with its weight. Summerwood is much heavier than springwood, hence it follows that the more summerwood a timber possesses, the stronger it

will be. For example, a strength test, made by the United States Forest Products Laboratory, Madison, Wis., on a certain southern yellow pine timber with 52 per cent of summerwood, showed it to be 1.6 times as strong as a piece having only 18 per cent. (See Fig. 7.) After many tests on timbers of varying amounts of summerwood, it was finally concluded that a high-class structural timber could be guaranteed if there were 33⅓ per cent of summerwood present, and the timber were free from injurious defects.

It was determined that the third, fourth and fifth inches on a radial line from the pith (center of the tree) came very close to having the same percentage of summerwood as the average of the whole cross-section of the timber. Hence it was concluded that a timber must show at least one-third summerwood in the third, fourth and fifth inches measured out from the pith to satisfy the strength requirements for exacting purposes. This rule can well be applied in the selection of Douglas fir timbers where much strength is needed, since some pieces have a low percentage of summerwood and are therefore low in strength.

Besides having one-third summerwood, a timber with a high strength value should be solid and free from serious defects such as injurious diagonal grain, loose or rotten knots, wide checks, decay or shake between the annual rings. The position of the knots has a great influence on the strength of timber. The most dangerous knots are those located in the bottom quarter of the middle half of the beam (volume 1). The next in order of danger, are those in the upper side near the middle of the span (volume 2), and the least dangerous are those along the center of the line of height (volume 3). Fairly large knots in volume 3 will not seriously affect the strength of a beam, but knots located in volume 1 may reduce its strength value 25 per cent below that of similar beams with knots located in other portions.

There is no grade made at present for Douglas fir which sets aside timbers possessing high-grade structural qualifications, and they must be selected from the ordinary grade of common fir timbers. This grade will usually provide good material for general constructional purposes, but since it includes pieces which vary considerably in density and in position of defects, the stock must be picked over if timbers of high strength value are required.

*Use of Proper Grade.*—The grades for Douglas fir embrace material just as well fitted for ordinary, every-day uses as for special, exacting ones. The consumer who demands timber that is practically free from defect for every kind of use is not practising good economy. High quality material of all kinds commands high prices, and if the

consumer insists on having the best grades of lumber he must pay what it is worth, just as he would pay an extra price for a choice cut of meat. For example, vertical-grain Douglas fir flooring costs more than flat-grain flooring because of the increased cost of manufacture. It is superior for flooring subject to hard wear since it does not splinter as much and wears longer than flat-grained material, but if the floor is to be carpeted, there would be little advantage in using it.

There are some uses on the farm where only first-class material will do, as for the construction of wood pipes and tanks which require that the staves shall be practically free from defects, but in many cases upper-grade lumber is used when a lower grade will amply serve the purpose. For instance, there is no need of putting as good a grade of material in an implement shed as in a grain storage building, since the building is not subjected to a heavy load as is the case with the granary. All that is necessary is to have the framing sufficiently strong to safely hold the wall and roof covering and to prevent collapse of the building from wind and snow. For this purpose studding of No. 2 dimension would probably prove as satisfactory as No. 1 dimension, and considerably reduce the cost of the building. Another example of the use of a better grade of material than is necessary is found in the use of high-class sheathing in roof construction. Since all that is required is to have the lumber strong enough to hold shingle nails well, a low grade of sheathing would serve just as well for this purpose at a saving of $3 to $4 per thousand feet.

*Use of Creosoted Material.*—Objections are often raised to the use of wood, Douglas fir in particular, for sills and foundations, because of its liability to damage by fungi or white ants which may render a timber useless in a few years. The difficulty has been that the wood has not been properly safeguarded against these destructive agencies. All but the most durable woods will deteriorate rapidly when placed in contact with the ground or with stone or concrete foundations. Also, decay is bad at joints and points of contact in any timber structure on account of the water which collects in such places. In such cases the life of the timber can be materially lengthened if the ends are given two coats of hot coal tar creosote. Girders or joists which rest in masonry walls should not be sealed in, but should have an air space of at least two inches around the end to allow ventilation.

The brush treatment is hardly sufficient for bridge timbers since the face of the planks would soon be worn away through travel and the action of winter freshets with their loads of driftwood. For this purpose timber thoroughly treated with preservative will give best satisfaction. It was formerly considered that creosoting decreased the

strength of Douglas fir timbers, but a process is now used which is less severe on the fibers of the wood than the original form of treatment. It is now possible to secure a thorough penetration of the wood without causing a material loss of strength.

There is no doubt that the use of creosoted material will greatly increase on the farm as its merits become known. Silo staves of non-durable woods are now being treated. Besides making them more resistant to decay, it renders them less subject to shrinking and swelling. Creosoted wood block is highly successful as a paving material, and there is no reason why its excellent qualities should not make it equally good for dairy-barn floors.

## REDWOOD

*Durability of Redwood.*—If it had no other merits, redwood would deserve a wide use on the farm because of its great natural resistance to rot and fire. Heart redwood when placed in contact with the ground should have an average life of 25 years, whereas some other native woods which could be bought a little cheaper, perhaps, rot out in a few years. When timbers are to be subjected to conditions favorable for decay, only a small amount of sapwood should be used because of its tendency to decay quickly. The heartwood is much more durable, owing to the presence of tannins, oils and resins which make it obnoxious to decay-producing fungi. The durable qualities of redwood should be taken advantage of by the farmer in his choice of wood for such uses as mud sills, flumes, stock tanks, headgates and well casings, where all the conditions promoting decay are present.

*Fire Resistance of Wood.*—The fire hazard on the farm is high because of the presence of large amounts of inflammable material, carelessness of employees and the lack of fire-fighting facilities. Redwood is particularly well adapted for buildings subject to fire exposure since it is hard to ignite and slow to burn, and fires are easily extinguished. The fire-resistant quality of redwood was well shown at the time of the great San Francisco fire in 1906 when the burned district was fringed with houses built with redwood which resisted the flames until they could be controlled.

*Relation of Qualities to Use.*—Redwood is light, but relative to its weight it is one of the strongest woods known. It is not especially elastic and consequently is not extensively used for structural purposes where timbers are subject to heavy loads. The wood is sufficiently strong and stiff, however, for general house-construction purposes, and in addition, is light and durable. These properties, as

well as its ability to keep its shape, make redwood especially valuable to poultry men, since it is essential that the joints in incubators and other poultry yard appliances resist rot and keep tight in all kinds of weather.

Redwood is an excellent wood for silos because of its durability, small amount of shrinkage and non-conducting properties. A redwood stave silo should last at least 20 years, and for its cost, is very economical as compared with that built of other materials. Although not as good as a stave silo, the resaw silo made of 6-inch redwood boards, nailed horizontally to upright $2 \times 4$ Douglas fir studdings with several layers of building paper placed between, or the wood-hoop silo,[4] has served many a California farmer very acceptably.

Wood pipe made from redwood or Douglas fir has many advantages as compared to cast-iron pipe for conveying water for irrigation. It is not so subject to injury from chemicals in the soil and does not readily expand or contract due to extremes of temperature. Also, repairs can be made quickly and cheaply. Wood stave pipe can be made smaller than that of other materials, since the low internal friction of the smooth inner surface permits the passage of a greater volume of water per unit of sectional area. Untreated Douglas fir is less durable than redwood when placed in the ground under conditions favoring rot. If treated with creosote, however, Douglas fir will equal redwood in durability and where high pressures are exerted its superior tensile strength gives it the preference. The average life of a wood pipe, when continually filled with water, is estimated by engineers to be about 25 years. Cases have been known where redwood pipe placed in contact with the soil has lasted fifty years.

Redwood makes a good shingle wood because of its durability and the slowness with which it burns. Zinc-coated or cut iron nails should be used, due to the tannin in the wood which quickly corrodes the ordinary shingle nail. If properly laid, a vertical grain No. 1 clear redwood shingle roof should last from 25 to 40 years. Redwood shakes, which are either sawed or split shingles, commonly 36 inches long, 6 inches wide and ¼ inch thick, without taper, are widely used in California for sidewall coverings of buildings because of the distinctive appearance which they give. Several different sizes can be had, the split shakes being considered superior to those that are sawed, because of the straightness of the grain.

*Use of Proper Grade.*—The upper grades of redwood, comprising clear, sap clear, and standard, come in lengths of from 8 to 20 feet

[4] The Construction of the Wood-Hoop Silo, Cir. 173, Agricultural Experiment Station, University of California, 1917.

and in widths from 3 inches up, command much better prices than the common grades which admit of a much higher percentage of defect. For ordinary uses about the farm, the common grades with the same range of widths and lengths are the most economical. Short, narrow lumber can be obtained in all grades, and is cheaper and better than the usual sizes for which custom has created a heavy demand. For example, barn rustic made from $1 \times 8$ inch boards is just as good and is from $3 to $5 per thousand cheaper than that made from $1 \times 12$ inch boards. Short pieces of clear lumber are from $5 to $7 per thousand cheaper than 12- and 14-foot lengths of the same grade. The construction grade is designed for ordinary construction purposes, and is free from defects which materially weaken the piece. Well-seasoned redwood of the extra merchantable grade is the best material to use for flumes and irrigation boxes. In their construction much short lumber can be used and the expense considerably reduced. The lowest grade of redwood, No. 3 common, is not well adapted for substantial construction work on account of its defects, but it can be used to advantage for subflooring or sheathing. For silos and tanks only the best grades of clear redwood should be used.

### BIGTREE

The wood of the bigtree is lighter and more brittle than that of the coast redwood, to which it is inferior in practically all respects except durability. Bigtree is cut into lumber to some extent, but its chief value is for posts, shakes and stakes for vineyards in the San Joaquin Valley. From one tree 14 feet in diameter, there were cut 12,000 $2 \times 2 \times 7$ grape stakes, 6,500 $4 \times 5 \times 7$ posts, and 15,000 shakes, 2 feet long and 6 inches wide, the total value of the product being nearly one thousand dollars. The use of this wood is local, and it is mentioned only to distinguish it from the coast redwood, with which it is often confused.

### WESTERN YELLOW PINE ("CALIFORNIA WHITE PINE")

*Relation of Properties to Use.*—Western yellow pine is advertised under the name of California white pine to convey the idea that it is in a class with the eastern white pine and sugar pine for finishing and factory material. Botanically, western yellow pine is classed with the hard or "yellow" pines, rather than with the soft or "white" pines, but this wood varies in its characteristics, depending on the character of the trees from which it is cut. Lumber cut from the smaller trees, commonly called "bull-pines," and out from the centers of the larger trees, is coarse-grained and rather resinous, resembling that

of the southern yellow pine. That cut from the outside of the larger trees is soft, uniform-textured and resembles the white pine in its characteristics. Much of the western yellow pine timber cut in California is so soft and white that it is used for the same purpose as the true white pine. In addition to being a widely used wood for doors, sash, finish, ceiling and flooring, western yellow pine serves admirably for general construction purposes throughout its range. It is extensively used for fruit boxes and drying trays because of its lightness, strength and ability to keep its shape.

Many of the retail yards in the Sacramento and San Joaquin valleys are stocked chiefly with timber cut in the Sierras, a large part of which is western yellow pine. The common grades of pine boards are made up of this species and sugar pine, and usually are sold under the name of mountain pine. This lumber is well adapted for all uses except those requiring special strength and durability. Mountain pine dimension material includes white fir in addition to these species, and sells at retail for a little less than Douglas fir, to which it is considerably inferior in strength and elasticity.

*Use of Treated Posts and Poles.*—Farmers in the foothills of the Sierras could utilize second-growth western yellow pine to good advantage for fence posts and telephone poles in case the butts were treated with a preservative. The wood is sufficiently strong for these purposes, but in its natural state it is lacking in durability. Round posts, such as can be cut at little expense from second-growth stands of western yellow pine, are well adapted for preservative treatment since they are largely sapwood, which takes preservative readily.

A fair estimate for the cost of an untreated pine post in the ground is 14 cents, compared to a cost of 25 cents for a treated post. The untreated post lasts only about five years and the treated post twenty years. When the interest and cost of replacement is figured for these periods, it will be found that the yearly cost of the treated post is about half that of the untreated post. The life of first-class redwood or cedar posts, which sell for 20 to 25 cents, does not exceed 20 years, and if the posts are sappy or the soil sandy, a much shorter life must be expected. As a general rule, a farmer with a plentiful supply of a non-durable timber, like western yellow pine, and a simple treating plant can save money in the long run over the cost of untreated posts of durable species.[5]

[5] A recent Farmers' Bulletin, No. 744, entitled "The Preservative Treatment of Farm Timbers," by Geo. M. Hunt, gives the kind of equipment needed and the method of treatment of different classes of timber on the farm. The bulletin may be obtained free of charge from the Editor and Chief of the Division of Publications, U. S. Dept. of Agriculture, Washington, D. C.

High-grade creosote oils suitable for treating farm timbers can be obtained through local dealers in gallon cans up to 25-gallon barrels at a cost of from 60 cents to 85 cents per gallon, depending on the quantity ordered. A barrel of good creosote is a good investment since the oil can be used to advantage for the treatment of any cheap, non-durable wood.

It is always a good plan to treat sills and foundation timbers in contact with the ground or with concrete foundations. Lumber used in greenhouses is usually subject to rapid decay, which can be greatly retarded by preservative treatment. Except where naturally durable woods are available, a preservative treatment will always prove economical for timber exposed to moisture and decay.

## SUGAR PINE

Sugar pine is considered the most valuable tree on the Pacific Coast, due to the excellent qualities of the wood and the amount of high-class lumber which can be obtained from it for finishing and remanufacturing purposes. The qualities which especially commend it to the artisan are the ease with which it can be worked and the slight shrinkage, swelling, and warping which takes place under varying atmospheric conditions. From 40 to 50 per cent of the cut consists of the upper grades, No. 2 shop and better, the greatest part of which is used for finishing purposes, and the manufacture of sash, doors, blinds, pattern stock and other special uses. In some parts of central California, sugar pine is used as a lining material for silos, for which use its appears well adapted because of its durability and ability to keep its shape.

Sugar pine is a favorite box material on account of its softness, lightness, light color, freedom from odor and taste, and because it can be nailed without splitting. A large proportion of the lumber included in the grades below No. 2 shop is made into fruit boxes, the balance of the lower grades being found in yards supplied by mills operating in the Sierras in the form of common boards and dimension material. Sugar pine is not as durable in contact with the ground as redwood or cedar, but in the air it shows great lasting properties. When handled by retailers, the lower grades are often included in the combination of woods known as mountain pine. Although poor in shock-resisting ability sugar pine is strong enough to be used for purposes where only moderate strength is required.

The early settlers in the Sierras found sugar pine well adapted for shakes, and the fruit men in the valleys below soon found out

its suitability for raisin and fruit trays. At first all this material was split out of straight-grained trees, causing much waste of material, but now it is principally sawed out by small shingle or tray mills.

### THE TRUE FIRS

There are three distinct species of true firs found in California which are more or less used on the farm. They are white fir and red fir, which grow in the Sierras, and lowland fir, which is found in the coast forests.

In the San Joaquin Valley considerable white fir is included in the grade of mountain pine. In a dry climate, it serves for cheap and temporary construction purposes, but it is not satisfactory when strength and durability are sought. Because of its tendency to split when nailed, it has but a limited use in the manufacture of fruit boxes, which are chiefly made of pine. Red fir is not extensively cut into lumber on account of the altitude at which it grows. It is stronger and much more durable than white fir and finds a ready use on mountain ranches in localities in which it grows.

Retailers who handle lumber cut in the coast region generally carry a common grade of white fir which grows there, which sells for about $3 less per thousand board feet than a similar grade of other species. This wood is neither durable nor strong, and has a tendency to warp and check, but it fulfills a certain need for cheap, temporary construction and for forms. A large part of the cut is made into a wall board which is different from the ordinary wall board made of wood pulp, in that it has a wooden core made firm by layers of cement surfaced with heavy paper. This makes a dry, sanitary and clean lining for walls and ceilings, and is especially good for remodeling the interior of buildings, since it can be quickly and easily applied.

### PORT ORFORD CEDAR ("WHITE CEDAR")

Port Orford cedar is a comparatively new wood in California, but it is rapidly growing in favor for farm use because of the combination of strength and durability which it possesses. The strength is due to the compact character of the wood, and the durability to the presence of an oil in the wood which gives it a very distinctive odor. It is a popular belief that this odor will repel insects and it is extensively used in closets and chests. The wood may act in this capacity when freshly cut, but it soon loses this quality as it dries out and loses its scent. Port Orford cedar, however, has sufficient excellent qualities to recommend it without that of being a repellent to insects.

Besides being strong and durable, Port Orford cedar is easily worked, keeps its shape and does not splinter under long and hard wear. These properties make it an excellent wood for underpinning, bridge material, barn boards, fencing and other purposes where a wood is required that will resist decay and yet be strong and wear well. The grade of common, which retails at from $25 to $30 per thousand feet, depending on the sizes desired, furnishes a tight-knotted material that is highly satisfactory for ordinary construction work on the farm. A cheaper grade, No. 3 common, which admits of larger and coarser defects, but not sufficient to prevent the use of each piece in full length and full widths for ordinary purposes, can be purchased for from $20 to $22 per thousand in yards carrying this wood. The upper grades of Port Orford cedar have a wide use for finishing material and command prices equal to those of any of the western softwoods.

## WESTERN RED CEDAR

Western red cedar is the most widely used shingle wood in the United States because of its lightness, slight shrinkage and expansion, durability and the ease with which the wood will take nails without splitting. It makes a roof that is not affected by weather conditions and which can be cheaply constructed and maintained. More trouble with shingle roofs has been experienced in the past due to poor construction and the use of improper nails than to any fault in the wood itself. Shingle manufacturers have met this difficulty by getting out a complete set of directions on the correct methods of laying shingles so as to insure a tight and durable roof.

For permanent construction only the higher grades of shingles, such as retail for about $3.50 per thousand, should be used. The best method of selecting shingles is by a trademark bearing the guarantee of the manufacturer. This indicates that the shingles have been inspected and hold true to specifications as regards sap, thickness, size and grain. A grade of shingles well suited for farm use requires that all the shingles be free from sap and that 80 per cent be free from defects. Only dry shingles should be used if they are to be stained. Shingles that are not to be stained should be wet thoroughly before laying.

Western red cedar has an extensive use as grape stakes for which redwood was used almost entirely a few years ago. The wood is well adapted for this use on account of its lightness and durability, and generally undersells redwood several dollars a thousand stakes.

There is relatively little red cedar lumber handled by retailers in California, but where available, it is used for the same purposes as redwood.

### INCENSE CEDAR

Incense cedar is found chiefly on the west slope of the Sierra Nevada Mountains in California, where it forms about 8 per cent of the stand. It is cut into lumber only to a limited extent because of the prevalence of "dry rot," the result of a fungus which attacks the heartwood, causing cavities which become filled with a dry, brownish substance that gives the name to the defect. Other names given the tree are red cedar, white cedar and post cedar.

Incense cedar is one of the most durable woods in the Sierras, the heartwood being extensively used by mountain ranchers for posts, poles and rails. Also it has a wide local use for stubs for poles of less durable species. When so used, it is set in the ground alongside the pole to which it is wired or bolted. It is usually the custom to split out timber for these uses, the value of the finished product averaging 16c to 18c for posts, $1.25 to $1.50 for poles, and 30c for stubs. It is estimated that the life of heart cedar for these purposes is from 20 to 25 years.

Occasionally it is possible to obtain incense cedar logs which are not affected with dry rot, and when this is the case, lumber of high quality can be secured. The small quantity of high-grade lumber obtained is used locally for outside trim and interior finish. The bulk of the material sawed out is for dimension stuff and rough construction work, such as sills, culverts and bridge plank, for which it is adapted because of its durability and wearing qualities. The grade of lumber used for these purposes is No. 1 and 2 common, which sells for from $20 to $27 per thousand in the local mountain markets. The grade lower than No. 2 common is generally so badly affected with dry rot that it is of little value, and sells for as low as $8 to $10 per thousand. The prohibitive cost of transportation and the relatively small quantity cut keeps this wood from competing with the coast redwood in the Sacramento and San Joaquin valleys and it finds little use there except in a small way for grape stakes and raisin trays.

### WESTERN HEMLOCK ("SILVER FIR")

There is considerable unfounded prejudice against this wood, which is partially due to the poor reputation of eastern hemlock, which is a very splintery, coarse-grained wood, and much inferior to the western species. It also gained a bad name because it was formerly

the practice for retailers to buy green lumber, with the result that deterioration took place in the yards in the seasoning process. The poor appearance of the lumber contrasted with that of the seasoned stock of other species made a poor impression on the average consumer.

If well seasoned, western hemlock makes a good wood for purposes where it is not exposed to the weather, as for the lining of granaries, since the wood is light, non-resinous, fairly strong, tough, close-grained and holds nails well. It is not a durable wood, however, and should not be placed in contact with the ground. Much of the higher grade material is made into ceiling which has considerable use in some localities, since it is cheaper and serves the purpose as well as some other species in the market. The same grades are made for hemlock as for Douglas fir, but it undersells that timber from $2 to $3 per thousand feet, chiefly because of the prejudice against it which still exists.

## PROPERTIES AND FARM USES OF HARDWOODS

The use of hardwoods on the farm is necessary for the repairing of farm implements, such as harvesters and wagons, and for other purposes, such as handles, spokes and poles, where special strength and toughness are required. Eastern woods such as oak, ash, hickory and maple are generally used, the native hardwoods being little used except in remote localities. They are rarely sawed into lumber, the practice being to rough out the pieces required and allow them to season before making them up into the articles for which they are intended.

The California oaks, of which there are a number of species, such as white oak, black oak, live oak and tanbark oak, find little use except as fuel. The old timber is generally too brittle and weak for purposes where strength is required, and it is only the young growth which has the necessary qualities for the needed purposes. Eastern white oak is stronger, harder and tougher than red oak or Japanese oak and is probably the most widely used of all hardwoods.

California laurel is a native hardwood the worth of which people have been slow to recognize. It is heavy, hard and strong, and will do the work of most hardwoods at a considerably lower cost. It is extensively sold to country trade by certain hardwood dealers in San Francisco for wagon bottoms, the price ranging from 6c to 9c per foot, depending on the width and thickness of the piece. The average range of prices for eastern oak is from 11c to 15c and for Japanese oak, 9c to 14c per foot. It has an extensive use for house

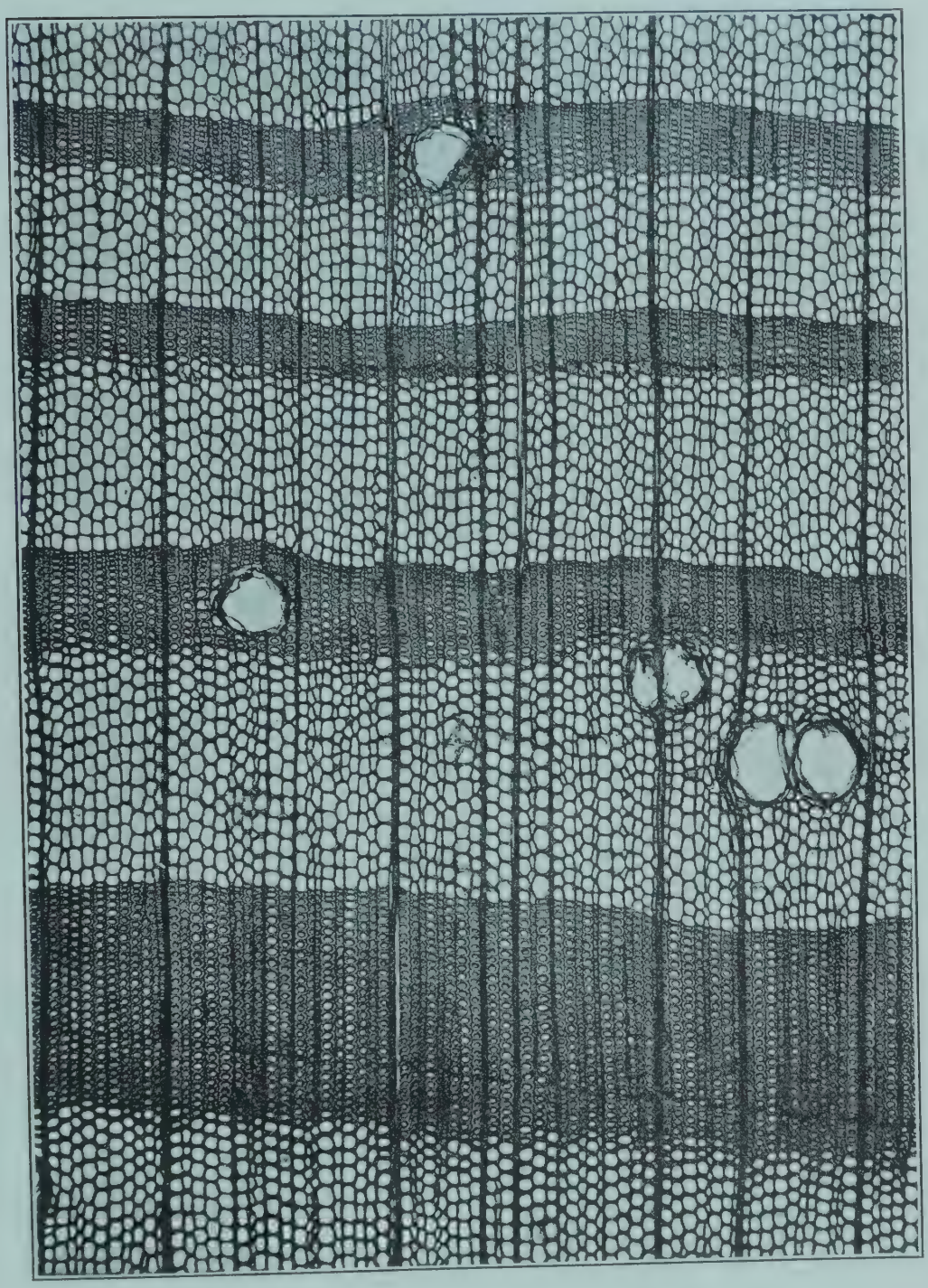


Fig. 8.—Longleaf pine, a non-porous wood. Cross-section showing several annual rings. Pores are absent and the structure is very uniform, due to the similar structure and arrangement of the wood elements. The growth rings are defined by the greater density of the summerwood. The larger openings seen are the resin ducts. The medullary rays appear as fine black lines.

rollers on account of its strength in compression, which is greater than that of oak.

Several species of the Australian genus Eucalyptus have been planted in California; extensive areas of blue gum having been set out with the idea of producing lumber in a short period of time. It has been well demonstrated, however, that satisfactory lumber can be obtained only from carefully selected large trees, since the wood from the small trees seasons so rapidly that excessive checking and warping takes place. The wood is very tough, hard and strong and is well adapted for small articles such as tool handles, brackets and insulator pins. A manufacturer of these articles is of the opinion that eucalyptus should displace 80 per cent of the eastern hardwoods used for these purposes.

In its natural state eucalyptus will not make a satisfactory post because of the rapid rate of decay of the sapwood. If treated with creosote by the open-tank method, however, the posts should give as good service as those of any other wood. A wide and very satisfactory use of eucalyptus is for fuel. Thoroughly seasoned wood compares favorably with oak in heating value, and where available, costs considerably less.

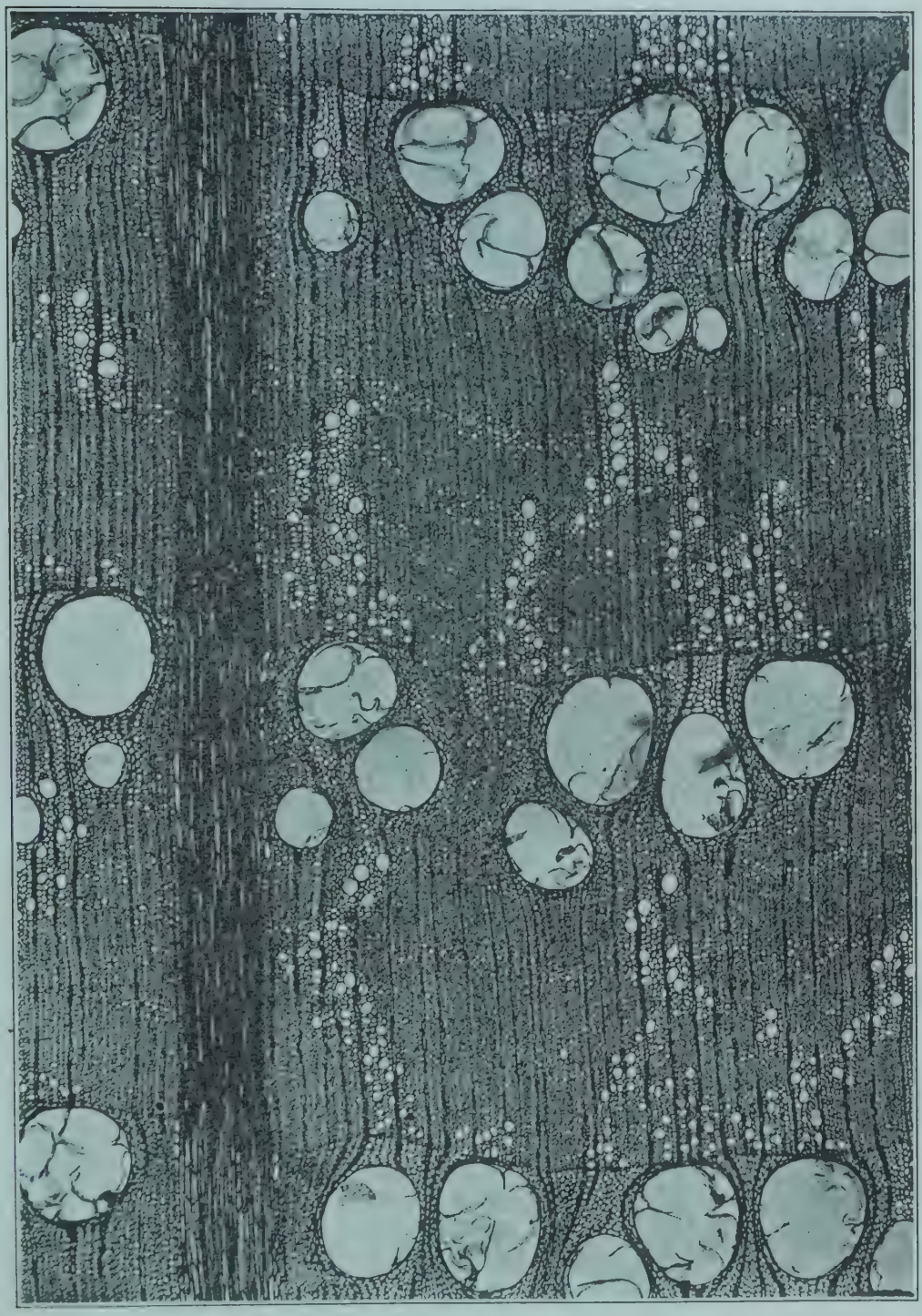
## KEY FOR IDENTIFICATION OF WOODS COMMONLY USED BY CALIFORNIA FARMERS

The purpose of this key is to arrange the main facts pertaining to the principal woods used by California farmers in such a way that they may be readily identified. The following terms, in addition to those already given, are used in connection with this key:

*Pores or Vessels.*—If the end of a piece of oak is examined, small holes called pores can be seen. These are cross-sections of small hollow tubular structures which serve to conduct the sap up the tree. These pores are found only in hardwoods, consequently softwoods are classified as "nonporous woods." (See Fig. 8.)

*Ring Porous.*—When there is a considerable difference in size between the pores in the springwood and summerwood, and the large pores are located in the springwood so that they form conspicuous concentric circles, as seen in the cross-section, the wood is said to be "ring porous." (See Fig. 9.)

*Diffuse Porous.*—If the pores are scattered throughout the annual ring and there is little difference between those in the springwood and those in the summerwood, the wood is said to be diffuse porous." (See Fig. 10.)



* Fig. 9.—White oak, a ring-porous wood. Cross-section through two annual rings. Large pores of spring wood are shown on lower portion of each growth ring. The small pores of the summer wood are in fan-like groups. Note large medullary ray to the left extending at right angles to the growth rings. Wood structure is complex, due to the lack of uniform structure and arrangement of the elements.

* Forest Service photo, Forest Products Laboratory, Madison, Wis.

*Resin Ducts.*—It may appear that in some of the conifers such as Douglas fir and pine, pores can be seen in cross-section. The small openings which appear, however, are cross-sections of canals which contain the resin produced by these species and are known as "resin ducts." They are absent in some softwoods, like cedar and redwood, and are never found in hardwoods. (See Fig. 8.)

## SUGGESTIONS FOR USING KEY

1. Cut a smooth cross-section from the end of the piece of wood under examination. The knife should be very sharp, since details of structure cannot be well observed if the surface is rough.

2. A magnifying glass of some kind, such as the ordinary hand lens, is of much assistance in bringing out the structural details of wood.

3. Softwoods can be distinguished from hardwoods by keeping in mind the following points:

| Softwoods | Hardwoods |
|---|---|
| *a.* Medullary rays not conspicuous. | *a.* Medullary rays generally conspicuous. |
| *b.* Some are resinous. | *b.* None are resinous. |
| *c.* Non-porous. | *c.* Pores present. |
| *d.* Easy to cut, as a rule. | *d.* Hard to cut, as a rule. |
| *e.* Wood generally light when dry. | *e.* Wood usually heavy when dry. |

4. The nature of the change between spring and summerwood, whether abrupt or gradual, is an important distinguishing characteristic in softwoods.

5. Some woods, such as redwood and bigtree, can be readily recognized by their color.

6. The smell of the wood is sufficient to distinguish the cedars. Moistening the surface brings out the odor more distinctly.

7. The pores in hardwoods should not be confused with the resin ducts in some of the conifers. The presence of resin can be detected by resinous exudations on the surface. Resin ducts often appear as brownish lines on longitudinal surfaces of dry lumber.

*Fig. 10.—Hard maple, a diffuse-porous wood. Cross-section through two annual rings. The pores are small and uniform in size in both spring and summer wood. The summer wood can be recognized by its greater density. The medullary rays are small, but quite distinct.

* Photos 8 and 10, Forest Service.

KEY FOR WOODS COMMONLY USED ON CALIFORNIA FARMS

I. Pores absent—*Conifers.*

A. Abrupt change between spring and summerwood.

1. Resinous.

a. Cross-section has appearance of cut-horn. Dark summerwood reddish in color. Wood moderately heavy. *Douglas Fir.*

b. Cross-section not horn-like in appearance. Heartwood reddish brown and darker than sapwood. Wood moderately light, some pieces only slightly resinous. *Western Yellow Pine.*

2. Non-resinous.

a. Color a dead white. Wood crumples under the knife in cross-section. Freshly cut pieces have strong, rancid odor. Wood checks and splits very easily. *White Fir.*

b. Color light brown. Wood cuts evenly in cross-section. Fresh pieces have sour odor. Takes nails well. *Western Hemlock.*

B. Gradual change between spring and summerwood.

1. Odorous.

a. Color white. Little change in color between sapwood and heartwood. Wood has strong, spicy odor and taste. *Port Orford Cedar.*

b. Color of heartwood light brown, sapwood whitish. Grain fine and uniform. Wood generally "pecky" due to dry rot. Faint aromatic odor. *Incense Cedar.*

c. Color reddish-brown. Wood rather coarse-grained. Agreeable odor, peculiar to cedar shingles. *Western Red Cedar.*

2. Odorless.

a. Color creamy white. Brown lines due to resin ducts found on radial and tangential surfaces. Wood of fine texture. *Sugar Pine.*

b. Color of heartwood red. Sapwood white and very narrow. Wood of coarse texture. *Redwood.*

c. Color of heartwood pinkish. Wood very light in weight. *Bigtree.*

II. Pores present—*Hardwoods.*

A. Ring porous (zone of large pores collected in springwood of annual ring).

1. Medullary rays large.

Large pores in 1–3 rows in springwood; change to smaller pores of summerwood abrupt. Wood heavy and hard. *White Oak.*

2. Medullary rays small.

a. Large pores in broad zone in springwood. Pores in summerwood small, scattered singly or in groups of short broken lines. Surface of wood light with a fine brown marking of lines running parallel with the grain. *White Ash.*

b. Large pores in springwood irregular, extending more or less into summerwood. Fine lines (not of pores) in summerwood extending parallel with the annual rings. Wood heavy, tough, hard and strong. *Hickory.*

B. Diffuse-porous (pores scattered uniformly throughout annual ring).

1. Annual rings absent or indistinct.

a. Rays very fine. Pores distributed in many lines. Color light brown. Wood very hard and tough. Interlaced fibers make it difficult to work. *Blue Gum.*

b. Rays fine but distinct. Pores occur singly or in small groups. Color pale white with dark streaks at intervals. Wood very hard and tough. Odor aromatic, taste peppery. *California Laurel.*

## LIST OF CIRCULARS DEALING WITH WESTERN SOFTWOODS

*Douglas Fir.*

Portland Lumber Co., 16 California st., San Francisco.

"Prosperity on your Dairy Farm."

West Coast Lumbermen's Association, Seattle, Wash.

"Creosoted Wood Stave Pipe for Irrigation Purposes."

"Creosoted Douglas Fir Paving Blocks."

"Creosoted Douglas Fir Road Culverts."

"Creosoted Fence Posts and Poles."

"Facts about Paving Bridge Floors."

"Lumber Users' Guide No. 8" (general description of Douglas fir).

*Redwood.*

California Redwood Assoc., 713 New Call Bldg., San Francisco.

"California Redwood on the Farm."

"The Test by Fire."

"Two Births."

"California Redwood Lives Forever."

*Pine.*

California Sugar and White Pine Co., San Francisco, Cal.

"California Sugar and White Pine."

*Port Orford Cedar and Hemlock.*

Information may be obtained from Coos Bay Lumber Company, Oakland, Cal.

*Western Red Cedar.*

West Coast Lumbermen's Association, Seattle, Wash.

"Lumber Users' Guide No. 12" (general description of Western Red Cedar).

"Farm Buildings of Red Cedar Shingles."

"Bungalow Houses of Red Cedar Shingles."

"Boys' Builder and Garage Book."

*Preservation.*

"The Preservative Treatment of Farm Timbers," George M. Hunt, Farmers' Bulletin 744, Forest Service, U. S. Dept. of Agr., 1916.

"Methods of Clearing Logged-off Land," C. H. Shattuck, Bulletin 91, Agricultural Experiment Station, University of Idaho, pp. 44–49, 1916.

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# COMMERCIAL FERTILIZERS

By P. L. HIBBARD

**BULLETIN No. 300**
NOVEMBER, 1918

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BENJAMIN IDE WHEELER, President of the University.

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# COMMERCIAL FERTILIZERS

By P. L. HIBBARD

This bulletin comprises the results of the fertilizer inspection work of the California Fertilizer Control for the fiscal year ending June 30, 1918.

## PURPOSE AND FUNCTIONS OF THE FERTILIZER CONTROL

The duty of the Fertilizer Control is: *

*First:* To issue certificates of registration to manufacturers and dealers who have complied with the law by filing a sworn statement of composition and sources of the fertilizers they wish to sell.

*Second:* To analyze these fertilizers as found in the open market and publish the results for the information of the public. If a manufacturer sells fertilizers which are materially below his guarantee in composition or value he is subject to prosectuion and fine. By this means it is intended to insure to purchasers that the fertilizers they buy shall be substantially as good as represented.

By a study of the reports of analyses of fertilizers, the consumer should be able to determine whether the materials he buys are sold for a fair price, and whether he obtains fertilizers of the desired composition. In short, the function of the Fertilizer Control is to see that the manufacturer gives the consumer a square deal.

## MAINTENANCE OF GUARANTEES

Every manufacturer is required by law to guarantee the percentage of nitrogen, phosphoric acid and potash in the fertilizers he sells. Owing to difficulties of sampling and analysis the law permits a maximum deficiency of 0.25% nitrogen, 1.00% phosphoric acid, 0.50% potash from the figures guaranteed. Greater deficiences than these are regarded as infractions of the law, and are indicated in the report of analyses in black faced type.

Some manufacturers uphold their guarantees better than others. The following table is a condensed report of the deficiences found in the main table of analyses. It summarizes the work done in this laboratory on each manufacturer's goods. The columns headed *Deficiencies—per cent of possible,* may be used for comparison of the various companies as to probability of meeting their guarantees. The other columns are necessary to show how these figures were obtained. In cases where very few analyses are reported for a manufacturer, the figures should be taken with caution, as perhaps not properly representative. When

* General Laws of California, Act 1157, Statutes of 1903, page 259 et seq.; approved March 20, 1903.

several samples of one manufacturer's goods were analysed the figures may be accepted as probably a fair indication of the reliability of his guarantee.

In general, manufacturers have more than maintained their guarantees, so that an average of all the analyses would show a substantial increase over the amount guaranteed.

MAINTENANCE OF GUARANTEES BY MANUFACTURER

| Manufacturer | Number of brands sampled | Number of samples analyzed | Total number of guarantees on samples analyzed | Deficiencies | | | |
|---|---|---|---|---|---|---|---|
| | | | | In guarantees | | In valuation | |
| | | | | No. | Per cent of possible | No. | Per cent of possible |
| Agricultural Chemical Works | 4 | 21 | 24 | 4 | 17 | 1 | 4 |
| American Agricultural Chemical Co | 3 | 6 | 18 | 0 | 0 | 0 | 0 |
| Anaheim Beef & Provision Co | 1 | 3 | 6 | 0 | 0 | 0 | 0 |
| Armour & Co | 4 | 10 | 23 | 2 | 9 | 0 | 0 |
| Rogers Brown & Co | 3 | 8 | 16 | 1 | 6 | 1 | 12 |
| California Fertilizer Works | 1 | 1 | 3 | 0 | 0 | 0 | 0 |
| Citrus Fertilizer Co | 4 | 8 | 24 | 1 | 4 | 0 | 0 |
| Cudahy Packing Co | 2 | 3 | 7 | 3 | .... | 1 | .... |
| Duffy's Guano Co | 1 | 1 | 3 | 0 | 0 | 0 | 0 |
| Fruit Growers Supply Co | 1 | 5 | 10 | 3 | 30 | 1 | 20 |
| General Fertilizer Assn | 4 | 14 | 37 | 11 | 30 | 4 | 28 |
| Germain Seed & Plant Co | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| Globe Grain & Milling Co | 6 | 12 | 20 | 1 | 5 | 1 | 8 |
| Hauser Packing Co | 5 | 36 | 75 | 16 | 21 | 4 | 11 |
| Oakland Meat & Packing Co | 1 | 4 | 8 | 1 | 12 | 0 | 0 |
| Pacific Bone Coal & Fertilizing Co | 4 | 6 | 12 | 1 | 8 | 0 | 0 |
| Pacific Guano & Fertilizer Co | 24 | 72 | 169 | 14 | 8 | 1 | 2 |
| Southern California Fertilizer Co | 3 | 9 | 26 | 0 | 0 | 0 | 0 |
| W. M. Warren Fertilizer Co | 1 | 1 | 3 | 0 | 0 | 0 | 0 |
| Western Meat Co | 7 | 56 | 135 | 9 | 7 | 0 | 0 |

*Owing to the possibility of misunderstanding, the figures for percentage deficiences are not given in above table in cases where less than four samples were analyzed.*

*Fertilizers sold on Station analysis, and some others, are not given a valuation in the table of analyses, hence the number of such samples is deducted from the total number analyzed, in computing deficiences in valuation.*

## SUMMARY OF DEFICIENCIES

In the analyses of the above samples, the following number of deficiencies greater than those allowed by law occured:

| | |
|---|---|
| Available phosphoric acid (total when available is not guaranteed) | 28 |
| Total nitrogen | 37 |
| Potash | 3 |
| In Valuation | 15 |

These deficiencies were found in 61 samples.

Of the total number of valuations reported in this bulletin 73% are above the amount guaranteed while 27% fall below.

## MECHANICAL CONDITION OF FERTILIZERS

A good degree of fineness is one of the essential qualities of a good fertilizer. It may be assumed that the finer the material the higher the availability, hence the consumer should insist on having finely ground fertilizers. Unfortunately, some manufacturers are at times careless in regard to the fineness of their goods. The insistent demand of the consumer is the most effective means of correcting such carelessness.

Besides the low agricultural availability and the difficulty in applying coarse fertilizers, it is almost impossible to obtain adequately representative samples of such goods for analysis. This is a prolific source of dissatisfaction and disagreement between buyers and sellers. During handling and transportation a coarsely ground tankage will separate so that the top of the sack contains the coarser material, high in nitrogen, while the bottom contains the finer parts of bone, high in phosphoric acid. A mixture of coarse bone meal with sulfate of potash will separate into coarse bone at the top and excess of potash at the bottom.

One of the chief reasons for the existence of the fertilizer manufacturer is that he is better prepared than the farmer to grind and mix the goods he sells, and the farmer should insist that he do it well.

## CAUTION IN REGARD TO LABELING FERTILIZER PACKAGES

The law expressly states that every package of fertilizer shall be accompanied by a plainly printed label giving the brand name, analysis, and source of the materials in the package. This requirement is not satisfactorily met by some manufacturers and dealers. Farmers are hereby cautioned that if they buy improperly or inadequately labeled fertilizers or goods not sold by properly registered dealers or their authorized agents they lose the protection afforded by the Fertilizer Control. Consumers should insist that fertilizer tags show plainly both the percentage and the derivation of each ingredient. A verbal state-

ment given by selling agent should not be accepted as adequate. The honest manufacturer is willing to guarantee his goods properly, and the farmer will best serve his own interests by dealing with no other.

## FERTILIZER VALUATIONS

The calculations of the commercial values of the fertilizers here reported are made on the so-called unit basis. Such calculations consist simply in multiplying the number of per cent of each ingredient by the price per unit and adding the products. The sum thus obtained is the commercial value per ton at the prices used. If it is desired to use such calculations for determining the amount which should be paid for goods, or the rebate to which the buyer is entitled, owing to the goods delivered being below the guaranty, it can only be satisfactorily done if a definite price per unit has been agreed upon between buyer and seller. But for the mere purpose of showing the relative values of goods to guaranties, it is not at all necessary that the prices adopted should be the exact market prices. Thus it is that the Fertilizer Control in attempting to show the relation between values found and values claimed, uses a schedule which is admittedly only an approximately average of market values. Owing to market fluctuations, differences in cost of delivery at different points, and other causes, the obtaining of true average market prices is an impossibility. But if the reader will bear in mind the true purpose of the valuations reported, these will have served their turn and he will not be led to assume that the experiment station is dictating the prices at which goods shall be sold.

## NOTE IN REGARD TO SCHEDULE OF VALUES

In view of the continued extraordinary increases in prices of fertilizers and of the chaotic condition of the market, we find it impossible again to prepare a schedule of prices by consultation of market reports as heretofore. Inasmuch, however, as such a schedule is necessary for comparative purposes, the following table of values has been prepared, based chiefly on known prices of recent sales in this state. These values are not to be taken as in any way representing actual present market prices, though they may sometimes approximate them. In the table of analyses the column "Value per ton" is given on the basis of station prices.

## SCHEDULE OF VALUES FOR 1918–1919

| | Per pound | Per unit |
|---|---|---|
| Nitrogen from blood | $0.31 | $6.20 |
| Nitrogen from tankage and bone | .30 | 6.00 |
| Nitrogen from sulphate of ammonia | .30 | 6.00 |
| Nitrogen from nitrate of soda | .30 | 6.00 |
| Phosphoric acid, available from rock super | .06 | 1.20 |
| Phosphoric acid, total from bone or tankage | .06 | 1.20 |
| Potash, water soluble | .20 | 4.00 |

## SCOPE OF INSPECTION

During the year 302 samples of fertilizers and fertilizing materials have been received at this laboratory. Of this number 13 were sent by farmers under the two-dollar fee provision, 186 were taken by inspectors from purchasers' goods upon the request of the purchasers, and 78 were taken by inspectors from goods in the hands of agents and manufacturers. 25 samples of a miscellaneous nature are omitted from the tables.

The following classification may be made of samples reported in this bulletin:

| | |
|---|---|
| Bat guano | 6 |
| Bird guano | 1 |
| Blood | 11 |
| Bone Meal | 34 |
| Complete fertilizer | 87 |
| Garbage tankage | 7 |
| Incomplete mixed fertilizer | 47 |
| Nitrate of soda | 7 |
| Sulphate of ammonia | 1 |
| Superphosphate | 3 |
| Tankage | 73 |

## REGISTERED MANUFACTURERS AND DEALERS

The following manufacturers and dealers in commercial fertilizers have obtained certificates of registration under the provisions of the California fertilizer law, for the fiscal year beginning July 1, 1917. A list is also given of the brands of fertilizers and fertilizer materials offered for sale by them. According to the sworn returns of dealers registered for the fiscal year ending June 30, 1917, their entire sales in the state amounted to 43,964 tons. Incomplete returns for the year ending June 30, 1918, indicate approximately 30,000 tons.

No dealer or manufacturer, except those who have certificates of

registration from the University of California, and their authorized agents, can legally sell fertilizers in this state. No person or company has any right to use any registration number except in connection with the firm name to which the registration certificate of such number has been issued; and no person or company to whom a registration number has been assigned has any right to give any other person or company permission to use said registration number; any number so used is a fraud. No agent has any right to use his principals' registration number in connection with his own name.

**Agricultural Chemical Works, Los Angeles, Cal.**

REGISTRATION No. 8

Bat Guano
Blood
Bone Meal
Fish Guano
Gypsum
Muriate of Potash
Nitrate of Soda
Sulphate of Ammonia
Sulphate of Potash
Superphosphate
Tankage
Special Mixtures to order

**American Agricultural Chemical Co., California Works, Los Angeles, Cal.**

REGISTRATION No. 1

Acid Phosphate
Blood
Bradley's California Vegetable
Bradley's Hay & Grain No. 1
Bradley's Hay & Grain No. 2
Bradley's Lawn
Bradley's Lemon Tree
Bradley's Nursery Stock
Bradley's Orange and Lemon
Bradley's Special Nursery Stock
Bradley's Tree and Vine
Fish Meal
Nitrate of Soda
Packers Fertilizer Assn. Special 4-10-1½
Raw Mineral Phosphate Rock
Sulphate of Ammonia
Sulphate of Potash
Tankage
Special Brands to order

**Anaheim Beef and Provision Company, Anaheim, Cal.**

REGISTRATION No. 88½

Tankage

**Rogers Brown & Co., Los Angeles, Cal.**

REGISTRATION No. 85

Blood
Bone Meal
Fish Meal
Tankage
Whale Bone Meal
Whale Meat and Blood
Whale Meat and Bone

**California Fertilizer Works, San Francisco, Cal.**

REGISTRATION No. 3

Special Mixtures to order

**Citrus Fertilizer Co., Los Angeles, Cal.**

REGISTRATION No. 87

Blood
Bone Meal
Doty's Fruiting
Doty's Nursery
Fish Meal
Fish Scrap
Guano
Nitrate of Soda
Phosphate Rock
Sulphate of Ammonia
Superphosphate
Tankage
Special Brands to order

**Clark & Clark, El Monte, Cal.**

REGISTRATION No. 93

Bird Guano

**Cudahy Packing Co., Los Angeles, Cal.**

REGISTRATION No. 79

A. & M. Superior Fish Meal
A. & M. Superior Brand Fish Meal
High Grade Blood
Low Grade Blood
High Grade Fish Meal
High Grade Fish Meal B
High Grade Tankage A, B
Low Grade Tankage
Special Lawn
Tankage Formula

**Duffy's Guano Company, Pasadena, Cal.**

REGISTRATION No. 91

Duffy's Guano
Duffy's Guano No. 2

**Fruit Growers Supply Company, Los Angeles, Cal.**

REGISTRATION No. 90

Blood
Bone
Nitrate of Soda
Tankage
Other Simples

**General Fertilizer Association, San Bernardino, Cal.**

REGISTRATION No. 42

Bat Guano
Bird Guano
Blood
Bone Meal
G. F. A. Root and Tuber
G. F. A. Special
Orange and Lemon No. 1
Tankage
Special Mixtures to order

**Germain Seed and Plant Co., Los Angeles, Cal.**

REGISTRATION No. 76

Blood and Bone
Nuvida Lawn and Garden
Nuvida Vegetable

**Globe Grain and Milling Co., Los Angeles, Cal.**

REGISTRATION No. 83

Bat Guano
Blood
Bone Tankage
Cottonseed Meal
Fish Meal
Lawn and Garden
Nitrate of Soda
Packing House Tankage
Steamed Bone Meal
Sulphate of Ammonia
Superphosphate
Tankage
Whale Bone Meal

**Hauser Packing Co., Los Angeles, Cal.**

REGISTRATION No. 33

High Grade Blood
High Grade Tankage
Low Grade Tankage
Nitrate of Soda
Steamed Bone Meal
Sulphate of Potash
Special Mixtures to order

**Hawaiian Fertilizer Co., Ltd., San Francisco, Cal.**

REGISTRATION No. 19

Bone Meal
Delta No. 1
Double Manure Salts
Dry Ground Blood
Fish Guano
Fruit and Vine
Fruiting
Muriate of Potash
Nitrate of Lime
Nitrate of Soda
Nursery
Special Fall
Special Spring
Sulphate of Ammonia
Sulphate of Potash
Superphosphate
Tankage
Thomas Phosphate
Vegetable
Whale Guano

**Mountain Copper Company, San Francisco, Cal.**

REGISTRATION No. 28

Mococo 0–14–9
Mococo 3–10–2
Mococo 3–10–5
Mococo 4–10–4
Mococo 4.1–10–1.5
Mococo Superphosphate 0–17–0
Nitrate of Soda
Sulphate of Potash
Special Mixtures to order.

**Oakland Meat and Packing Co., Emeryville, Cal.**

REGISTRATION No. 24

"Special"

**Pacific Bone, Coal and Fertilizing Co., San Francisco, Cal.**

REGISTRATION No. 14

Blood
Bone Meal
Citrona Special
Flora Special
Lupin Special
Nitrate of Soda
Nursery Special
Pomona Special
Superphosphate
Sulphate of Ammonia
Tankage
Special Formulas

**Pacific Guano and Fertilizer Co., San Francisco, Cal.**

REGISTRATION No. 4

Gaviota AJX
Gaviota CJV
Gaviota F&V
Gaviota GG
Gaviota HOP
Gaviota IXL
Gaviota N
Gaviota OK
Gaviota PNK
Gaviota PP
Gaviota S
Gaviota TRK
Gaviota VGR
Gaviota XLT
Gromore
Special Cropmaker
Superphosphate Cresco
Superphosphate Pacific
Special Mixtures to Order

**Pacific Wood and Coal Co., San Diego, Cal.**

REGISTRATION No. 53

Diamond BG Complete
Diamond BG Lawn
Diamond Bone Meal
Diamond Fish Meal
Diamond Tankage
Nitrate of Soda
Phosphoric Acid

**San Antonio Meat Co., Pomona, Cal.**

REGISTRATION No. 69

Tankage

**Southern California Fertilizer Co., Los Angeles, Cal.**

REGISTRATION No. 89

Garbage Tankage

**Union Superphosphate Co., San Francisco, Cal.**

REGISTRATION No. 31

Superphosphate, Cresco
Superphosphate, Pacific

**W. M. Warren Fertilizing Co., Covina, Cal.**

REGISTRATION No. 92

Bat Guano
Bird Guano
Blood
Bone Meal
Fish Meal
Special I
Special II
Tankage

**Western Fertilizer Co., San Francisco, Cal.**

REGISTRATION No. 68

Wizard
Wonder

**Western Meat Co., San Francisco, Cal.**

REGISTRATION No. 11

Brands A, B, C, D,
Brand E Tankage
Brand F Raw Bone
Brand G Steamed Bone
Brand H Blood
Brand I Tankage
Brands K, L, M, O
Brand R Special
Brand S Special
Fair Green
Lemon Special
Nitrate of Soda
Odorless Lawn Dressing
Putting Green
Sulphate of Potash
Superphosphate
Tankage
Special Brands to Order

**Wilson & Company, Los Angeles, Cal.**

REGISTRATION No. 64

High Grade Blood
High Grade Tankage
Fish Meal
Lawn and Garden
Low Grade Tankage
Nitrate of Soda
Nursery Special
Raw Bone Meal
Steamed Bone Meal
Superphosphate
Special Mixtures to Order

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Agricultural Chemical Works, Los Angeles, Cal.** | | |
| 7251* | Fine Ground Bone | S. G. Rossiter, Rialto | 47.33 |
| | *Guaranteed* | | *45.60* |
| 7352 | Potato | Anaheim Citrus Fruit Assn., Anaheim | **31.33** |
| | *Guaranteed* | | *34.80* |
| 7093 | Special | E. A. Moore, Redlands | 45.68 |
| | *Guaranteed* | | *44.40* |
| 7106 | Special | E. A. Moore, Redlands | 50.95 |
| | *Guaranteed* | | *48.00* |
| 7107 | Special | E. A. Moore, Redlands | 35.09 |
| 7145 | Special | J. M. Webster, Upland | 32.56 |
| 7248 | Special | J. D. Spenetta, Orange | 34.98 |
| 7249 | Special | J. D. Spenetta, Orange | 34.37 |
| | *Guaranteed* | | *33.60* |
| 7121 | Special | G. A. Herdeg, Riverside | 40.59 |
| 7122 | Special | G. A. Herdeg, Riverside | 40.87 |
| 7250 | Special | J. D. Spenetta, Orange | 40.34 |
| | *Guaranteed* | | *40.80* |
| 7123 | Special | G. A. Herdeg, Riverside | 34.77 |
| 7146 | Special | J. M. Webster, Upland | 35.90 |
| 7246 | Special | J. D. Spenetta, Orange | 36.16 |
| 7351 | Special | Anaheim Citrus Fruit Assn., Anaheim | 35.18 |
| | *Guaranteed* | | *36.00* |
| 7229 | Special | Anaheim Citrus Fruit Assn., Anaheim | 33.00 |
| | *Guaranteed* | | *32.00* |
| 7230 | Special | Anaheim Citrus Fruit Assn., Anaheim | 30.96 |
| | *Guaranteed* | | *31.20* |
| 7247 | Special | J. D. Spenetta, Orange | 38.52 |
| 7097 | Special | G. A. Herdeg, Riverside | 40.66 |
| | *Guaranteed* | | *38.40* |
| 7266 | Special | H. A. Lake, Garden Grove | 30.84 |
| | *Guaranteed* | | *28.80* |
| 7357 | Special | R. T. Nelson, Upland | 37.68 |
| | *Guaranteed* | | *36.00* |
| | **American Agricultural Chemical Co., Los Angeles, Cal.** | | |
| 7114 | Bradley's Calif. Vegetable | E. M. Cope Commercial Co., Redlands | 36.91 |
| | *Guaranteed* | | *34.64* |
| 7115 | Bradley's Lawn | E. M. Cope Commercial Co., Redlands | 36.56 |
| 7118 | Bradley's Lawn | G. L. Winterbotham, Riverside | 36.36 |
| 7271 | Bradley's Lawn | Morris & Snow Seed Co., Los Angeles | 36.39 |
| | *Guaranteed* | | *34.68* |
| 7116 | Bradley's Nursery Stock | E. M. Cope Commercial Co., Redlands | 37.22 |
| 7117 | Bradley's Nursery Stock | G. L. Winterbotham, Riverside | 36.02 |
| | *Guaranteed* | | *34.68* |
| | **Anaheim Beef & Provision Co., Anaheim, Cal.** | | |
| 7244* | Tankage | Manufacturer's Warehouse | 48.43 |
| | *Guaranteed* | | *46.37* |
| 7245* | Tankage | Manufacturer's Warehouse | 47.04 |
| | *Guaranteed* | | *25.88* |
| 7306* | Tankage | Perkins Bros., Santa Ana | 49.13 |
| | *Guaranteed* | | *48.20* |
| | **Armour Fertilizer Works, Los Angeles, Cal.** | | |
| 7063* | Bone Meal | Azusa Foot-Hill Citrus Assn., Azusa | 46.18 |
| | *Guaranteed* | | *46.08* |

*7251—46% fine.
*7244—73% fine.
*7245—71% fine.
*7306—83% fine.
*7063—66% fine.

NOTE. See page 152 for text referring to table of analysis

| | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab. No. | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen Guaranteed as derived from | Total | From Sulfate | Total | Ch Ri |
| 7251 | ..... | ..... | 23.00 | ..... | ..... | ..... | 4.11 | ..... | 4.11 | ..... | ..... | ... |
| ..... | ..... | ..... | *23.00* | ..... | ..... | ..... | *3.75* | ..... | *3.75* | ..... | ..... | ... |
| 7352 | 5.50 | 3.50 | 9.00 | ..... | 2.07 | ..... | 1.47 | ..... | **3.54** | ..... | **1.77** | 1 |
| ..... | *5.00* | *3.00* | *8.00* | *Bn, Super, T* | *2.00* | ..... | *2.00* | *Bat G, Bl, Bn* | *4.00* | ..... | *3.00* | ... |
| 7093 | ..... | ..... | 8.75 | ..... | ..... | 2.63 | 4.70 | ..... | 7.33 | ..... | ..... | ... |
| ..... | ..... | ..... | *9.00* | *Bn, Super, T* | ..... | *3.00* | *4.00* | *Bat G, Bl, Bn, Fs* | *7.00* | ..... | ..... | ... |
| 7106 | ..... | ..... | 8.50 | ..... | ..... | 3.55 | 4.94 | ..... | 8.49 | ..... | ..... | ... |
| ..... | ..... | ..... | *8.00* | *Bn, Super, T* | ..... | *4.00* | *4.00* | *Bat G, Bl, Bn, Fs* | *8.00* | ..... | ..... | ... |
| 7107 | ..... | ..... | 12.60 | ..... | 1.62 | ..... | 2.54 | ..... | 4.16 | ..... | ..... | ... |
| 7145 | ..... | ..... | 12.45 | ..... | 2.08 | ..... | 1.59 | ..... | **3.67** | ..... | ..... | ... |
| 7248 | ..... | ..... | 12.55 | ..... | 1.85 | ..... | 2.30 | ..... | 4.15 | ..... | ..... | ... |
| 7249 | ..... | ..... | 11.80 | ..... | 0.83 | ..... | 3.38 | ..... | 4.21 | ..... | ..... | ... |
| ..... | ..... | ..... | *12.00* | *Bn, Super, T* | *2.00* | ..... | *2.00* | *Bat G, Bl, Bn, Fs* | *4.00* | ..... | ..... | ... |
| 7121 | ..... | ..... | 10.35 | ..... | 1.84 | ..... | 4.03 | ..... | 5.87 | ..... | ..... | ... |
| 7122 | ..... | ..... | 10.30 | ..... | 1.74 | ..... | 4.20 | ..... | 5.94 | ..... | ..... | ... |
| 7250 | ..... | ..... | 10.10 | ..... | 1.67 | ..... | 4.21 | ..... | 5.88 | ..... | ..... | ... |
| ..... | ..... | ..... | *10.00* | *Bn, Super, T* | *2.00* | ..... | *4.00* | *Bat G, Bl, Bn* | *6.00* | ..... | ..... | ... |
| 7123 | ..... | ..... | 10.10 | ..... | 2.39 | ..... | 2.33 | ..... | **4.72** | ..... | ..... | ... |
| 7146 | ..... | ..... | 10.60 | ..... | 2.26 | ..... | 2.57 | ..... | 4.83 | ..... | ..... | ... |
| 7246 | ..... | ..... | 10.05 | ..... | 2.32 | ..... | 2.70 | ..... | 5.02 | ..... | ..... | ... |
| 7351 | ..... | ..... | 10.20 | ..... | 2.33 | ..... | 2.45 | ..... | 4.78 | ..... | ..... | ... |
| ..... | ..... | ..... | *10.00* | *Bn, Super,* | *2.00* | ..... | *3.00* | *Bat G, Bl, Bn, Fs* | *5.00* | ..... | ..... | ... |
| 7229 | ..... | ..... | 12.05 | ..... | 0.51 | 1.38 | 2.17 | ..... | 4.06 | ..... | ..... | ... |
| ..... | ..... | ..... | *12.00* | *Bn, Super T,* | *1.00* | *1.00* | *2.00* | *Bat G, Bl, Bn* | *4.00* | ..... | ..... | ... |
| 7230 | ..... | ..... | 6.20 | ..... | 1.78 | ..... | 3.12 | ..... | 4.90 | ..... | ..... | ... |
| ..... | ..... | ..... | *6.00* | *Bn, Super, T* | *2.00* | ..... | *3.00* | *Bat G, Bl, Bn, Fs* | *5.00* | ..... | ..... | ... |
| 7247 | ..... | ..... | 11.70 | ..... | 2.24 | ..... | 2.86 | ..... | 5.10 | ..... | ..... | ... |
| 7097 | ..... | ..... | 12.60 | ..... | 1.95 | ..... | 3.37 | ..... | 5.32 | ..... | ..... | ... |
| ..... | ..... | ..... | *12.00* | *Bn, Super, T* | *2.00* | ..... | *3.00* | *Bat G, Bl, Bn* | *5.00* | ..... | ..... | ... |
| 7266 | ..... | ..... | 8.30 | ..... | 2.35 | ..... | 2.00 | ..... | 4.35 | ..... | ..... | ... |
| ..... | ..... | ..... | *8.00* | *Bn, Super, T* | *2.00* | ..... | *2.00* | *Bat G, Bl, Bn, Fs* | *4.00* | ..... | ..... | ... |
| 7357 | ..... | ..... | 11.80 | ..... | 2.55 | 0.72 | 1.72 | ..... | 4.90 | ..... | ..... | ... |
| ..... | ..... | ..... | *10.00* | *Bn, Super, T* | *3.00* | ..... | *2.00* | *Bat G, Bl, Bn, Fs* | *5.00* | ..... | ..... | ... |
| 7117 | 8.23 | 1.08 | 9.40 | ..... | 1.87 | 0.80 | 0.72 | ..... | 3.39 | 4.68 | ..... | ... |
| ..... | *8.00* | *1.00* | *9.00* | *Bn, Super* | *1.90* | *0.60* | *0.80* | *Bat G, Bl, Bn, T* | *3.30* | *4.00* | ..... | ... |
| 7115 | 9.07 | 1.28 | 10.35 | ..... | 2.30 | 0.95 | 0.96 | ..... | 4.21 | 1.97 | ..... | ... |
| 7118 | 9.51 | 1.34 | 10.85 | ..... | 2.49 | 0.79 | 0.85 | ..... | 4.13 | 1.76 | ..... | ... |
| 7271 | 9.36 | 1.14 | 10.50 | ..... | 2.40 | 0.73 | 1.01 | ..... | 4.14 | 1.96 | ..... | ... |
| ..... | *9.00* | *1.00* | *10.00* | *Bn, Super* | *2.35* | *0.75* | *1.00* | *Bat G, Bl, Bn, T* | *4.10* | *1.50* | ..... | ... |
| 7116 | 9.75 | 1.20 | 10.95 | ..... | 2.50 | 0.69 | 1.04 | ..... | 4.23 | 1.89 | ..... | ... |
| 7117 | 9.34 | 1.36 | 10.70 | ..... | 2.48 | 0.85 | 0.77 | ..... | 4.10 | 1.75 | ..... | ... |
| ..... | *9.00* | *1.00* | *10.00* | *Bn, Super* | *2.35* | *0.75* | *1.00* | *Bat G, Bl, Bn, T* | *4.10* | *1.50* | ..... | ... |
| 7244 | ..... | ..... | 14.40 | ..... | ..... | ..... | 6.49 | ..... | 6.49 | ..... | ..... | ... |
| ..... | ..... | ..... | *12.00* | ..... | ..... | ..... | *6.66* | ..... | *6.66* | ..... | ..... | ... |
| 7245 | ..... | ..... | 13.00 | ..... | ..... | ..... | 6.55 | ..... | 6.55 | ..... | ..... | ... |
| ..... | ..... | ..... | *4.15* | ..... | ..... | ..... | *4.25* | ..... | *4.25* | ..... | ..... | ... |
| 7306 | ..... | ..... | 13.10 | ..... | ..... | ..... | 6.96 | ..... | 6.96 | ..... | ..... | ... |
| ..... | ..... | ..... | *12.00* | ..... | ..... | ..... | *6.00* | ..... | *6.00* | ..... | ..... | ... |
| 7063 | ..... | ..... | 27.80 | ..... | ..... | ..... | 2.67 | ..... | 2.67 | ..... | ..... | ... |
| ..... | ..... | ..... | *28.00* | ..... | ..... | ..... | *2.60* | ..... | *2.60* | ..... | ..... | ... |

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Armour Fertilizer Works,** (Continued.) **Los Angeles, Cal.** | | |
| 7061* | Bone Meal | Azusa Foot-Hill Citrus Assn., Azusa | 45.29 |
| 7065* | Bone Meal | Azusa Foot-Hill Citrus Assn., Azusa | 45.22 |
| | *Guaranteed* | | *44.46* |
| 7066* | Bone Meal | Azusa Foot-Hill Citrus Assn., Azusa | 44.16 |
| | *Guaranteed* | | *43.20* |
| 7067* | Bone Meal | Azusa Foot-Hill Citrus Assn., Azusa | 44.59 |
| | *Guaranteed* | | *42.72* |
| 7068* | Bone Meal | Azusa Foot-Hill Citrus Assn., Azusa | 45.17 |
| | *Guaranteed* | | *45.12* |
| 7071 | Cropmaker Special | W. T. Henderson, Riverside | 36.84 |
| | *Guaranteed* | | *3520.* |
| 7072 | Special 4–10–1 | W. T. Henderson, Riverside | 34.42 |
| | *Guaranteed* | | *33.20* |
| 7073 | Special 4–10–1 | W. T. Henderson, Riverside | 33.67 |
| | *Guaranteed* | | *33.20* |
| 7136* | Tankage | E. R. Brubaker, et al, Azusa | 46.44 |
| | *Guaranteed* | | *48.56* |
| | **Rogers Brown & Co., Los Angeles, Cal.** | | |
| 7082* | Bone Meal | J. Henry Reynolds, Redlands | 47.50 |
| 7224* | Bone Meal | General Fertilizer Assn., Ontario | 45.65 |
| 7360* | Bone Meal | R. W. Hamlin, Glendora | 43.78 |
| | *Guaranteed* | | *42.00* |
| 7089* | Whale Bone Meal | J. Henry Reynolds, Redlands | 50.14 |
| | *Guaranteed* | | *45.60* |
| 7191* | Bone Meal | C. A. Griffith, Azusa | 46.44 |
| | *Guaranteed* | | *47.28* |
| 7346* | Fish Meal | W. M. Warren, Covina | 60.98 |
| | *Guaranteed* | | *59.52* |
| 7335* | Fish Scrap | Henry Fuller, Redlands | **51.60** |
| | *Guaranteed* | | *55.80* |
| 7324* | Fish Tankage | D. B. Lee, Ontario | 56.23 |
| | *Guaranteed* | | *55.76* |
| | **California Fertilizer Works, San Francisco Cal.** | | |
| 7176* | Special | G. A. Hanson, Upland | 37.82 |
| | *Guaranteed* | | *39.00* |
| | **Citrus Fertilizer Co., Los Angeles, Cal.** | | |
| 7090 | Doty's Fruiting | E. E. Cole, Redlands | 31.92 |
| 7178 | Doty's Fruiting | G. R. Tyler, Pomona | 29.96 |
| | *Guaranteed* | | *28.80* |
| 7091 | Doty's Nursery | E. E. Cole, Redlands | 38.93 |
| 7177 | Doty's Nursery | G. R. Tyler, Pomona | 35.70 |
| 7179 | Doty's Nursery | G. R. Tyler, Pomona | 37.58 |
| 7208 | Doty's Nursery | G. R. Tyler, Pomona | 34.34 |
| 7275 | Doty's Nursery | Erasmus Wilson, San Gabriel | 44.46 |
| | *Guaranteed* | | *34.20* |
| 7092 | Bird Guano (Doty's) | E. E. Cole, Redlands | 70.96 |
| | *Guaranteed* | | *56.30* |
| | **Cudahy Packing Co., Los Angeles, Cal.** | | |
| 7253 | Blood | General Fertilizer Assn., San Bernardino | 70.04 |
| | *Guaranteed* | | *70.20* |
| 7252* | Fish Meal | General Fertilizer Assn., San Bernardino | 56.84 |
| | *Guaranteed* | | *55.20* |
| 7347* | Fish Meal | E. E. Kaiser, Covina | **48.41** |
| | *Guaranteed* | | *58.16* |
| | **Duffy's Guano Co., Pasadena Cal.** | | |
| 7214 | Duffy's Guano No. 2 | Percy Willetts, Pasadena | 14.88 |
| | *Guaranteed* | | *14.40* |

*7064—70% fine.
*7065—71% fine.
*7066—75% fine.
*7067—72% fine.
*7068—68% fine.
*7136—69% fine.
*7082—66% fine.
*7224—58% fine.
*7360—61% fine.
*7089—51% fine.
*7191—63% fine.
*7346—53% fine.
*7335—56% fine.
*7324—64% fine.
*7176—No statement of derivation. In violation of California Fertilizer Act.
*7252—76% fine.
*7347—65% fine.

| | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab. No. | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen Guaranteed as derived from | Total | From Sulfate | Total | Chlorine |
| 7064 | ..... | ..... | 28.70 | ..... | ..... | ..... | 2.26 | ..... | 2.26 | ..... | ..... | ..... |
| 7065 | ..... | ..... | 27.60 | ..... | ..... | ..... | 2.52 | ..... | 2.52 | ..... | ..... | ..... |
| ..... | ..... | ..... | *27.00* | ..... | ..... | ..... | *2.50* | ..... | *2.50* | ..... | ..... | ..... |
| 7066 | ..... | ..... | 26.80 | ..... | ..... | ..... | 2.50 | ..... | 2.50 | ..... | ..... | ..... |
| ..... | ..... | ..... | *26.00* | ..... | ..... | ..... | *2.50* | ..... | *2.50* | ..... | ..... | ..... |
| 7067 | ..... | ..... | 27.00 | ..... | ..... | ..... | 2.54 | ..... | 2.54 | ..... | ..... | ..... |
| ..... | ..... | ..... | *26.00* | ..... | ..... | ..... | *2.40* | ..... | *2.40* | ..... | ..... | ..... |
| 7068 | ..... | ..... | 28.20 | ..... | ..... | ..... | 2.36 | ..... | 2.36 | ..... | ..... | ..... |
| ..... | ..... | ..... | *28.00* | ..... | ..... | ..... | *2.40* | ..... | *2.40* | ..... | ..... | ..... |
| 7071 | 7.27 | 3.68 | 10.95 | ..... | 1.39 | ..... | 2.61 | ..... | 4.00 | 2.25 | ..... | 1.2 |
| ..... | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *1.50* | ..... | *2.50* | *Bl, Bn, G, T* | *4.00* | *2.00* | ..... | ..... |
| 7072 | **5.98** | 4.52 | 10.50 | ..... | 1.35 | 1.54 | 1.21 | ..... | 4.10 | 1.07 | ..... | ..... |
| ..... | *7.50* | *2.50* | *10.00* | *Bn, G, Super* | *1.50* | *1.50* | *1.00* | *Bl, Bn, G, T* | *4.00* | *1.00* | ..... | ..... |
| 7073 | 5.80 | 5.20 | 11.00 | ..... | 1.45 | ..... | 2.44 | ..... | 3.89 | 0.90 | ..... | 0.6 |
| ..... | *6.50* | *3.50* | *10.00* | *Bn, G, Super* | *1.50* | ..... | *2.50* | *Bl, Bn, G, T* | *4.00* | *1.00* | ..... | ..... |
| 7136 | ..... | ..... | **14.30** | ..... | ..... | ..... | 6.10 | ..... | 6.10 | ..... | ..... | ..... |
| ..... | ..... | ..... | *15.71* | ..... | ..... | ..... | *6.19* | ..... | *6.19* | ..... | ..... | ..... |
| 7082 | ..... | ..... | 28.50 | ..... | ..... | ..... | 2.77 | ..... | 2.77 | ..... | ..... | ..... |
| 7224 | ..... | ..... | 27.80 | ..... | ..... | ..... | 2.56 | ..... | 2.56 | ..... | ..... | ..... |
| 7360 | ..... | ..... | 27.80 | ..... | ..... | ..... | 2.17 | ..... | 2.17 | ..... | ..... | ..... |
| ..... | ..... | ..... | *27.00* | ..... | ..... | ..... | *2.00* | ..... | *2.00* | ..... | ..... | ..... |
| 7089 | ..... | ..... | 27.30 | ..... | ..... | ..... | 3.62 | ..... | 3.62 | ..... | ..... | ..... |
| ..... | ..... | ..... | *26.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 7191 | ..... | ..... | 28.70 | ..... | ..... | ..... | 2.50 | ..... | 2.50 | ..... | ..... | ..... |
| ..... | ..... | ..... | *29.00* | ..... | ..... | ..... | *2.60* | ..... | *2.60* | ..... | ..... | ..... |
| 7346 | ..... | ..... | 6.90 | ..... | ..... | ..... | 10.98 | ..... | 10.98 | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.60* | ..... | ..... | ..... | *11.00* | ..... | *11.00* | ..... | ..... | ..... |
| 7335 | ..... | ..... | 8.00 | ..... | ..... | ..... | 8.75 | ..... | **8.75** | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.50* | ..... | ..... | ..... | *9.50* | ..... | *9.50* | ..... | ..... | ..... |
| 7324 | ..... | ..... | 10.30 | ..... | ..... | ..... | 9.14 | ..... | 9.14 | ..... | ..... | ..... |
| ..... | ..... | ..... | *9.63* | ..... | ..... | ..... | *9.21* | ..... | *9.21* | ..... | ..... | ..... |
| 7176 | ..... | ..... | 13.40 | ..... | 1.15 | 0.48 | 2.25 | ..... | 3.88 | ..... | 1.56 | 1.0 |
| ..... | ..... | ..... | *14.00* | ..... | ..... | ..... | ..... | ..... | *4.00* | ..... | *1.50* | ..... |
| 7090 | 7.38 | 1.62 | 9.00 | ..... | 1.39 | ..... | 1.74 | ..... | 3.13 | ..... | 3.05 | 2.0 |
| 7178 | 6.88 | 2.32 | 9.20 | ..... | 0.69 | ..... | 1.98 | ..... | **2.67** | ..... | 3.05 | 0.9 |
| ..... | *7.00* | ..... | ..... | *Bn, Super, G, T* | *1.00* | ..... | *2.00* | *Bn, G, T,* | *3.00* | *3.00* | ..... | ..... |
| 7091 | ..... | ..... | 8.60 | ..... | 2.58 | ..... | 2.51 | ..... | 5.09 | ..... | 2.09 | 1.0 |
| 7177 | ..... | ..... | 6.60 | ..... | 1.76 | ..... | 3.31 | ..... | 5.07 | ..... | 1.72 | 1.3 |
| 7179 | ..... | ..... | 8.90 | ..... | 1.87 | ..... | 3.00 | ..... | 4.87 | 1.76 | ..... | 0.6 |
| 7208 | ..... | ..... | 6.15 | ..... | 1.54 | ..... | 3.44 | ..... | 4.98 | 1.53 | ..... | 0.8 |
| 7275 | ..... | ..... | 9.00 | ..... | 1.19 | 0.69 | 4.09 | ..... | 5.97 | ..... | 2.50 | 1.3 |
| ..... | ..... | ..... | *6.00* | *Bn, Super, G, T* | *2.00* | ..... | *3.00* | *Bn, G, T* | *5.00* | *1.50* | ..... | ..... |
| 7092 | ..... | ..... | 13.25 | ..... | ..... | 3.59 | 7.39 | ..... | 10.98 | ..... | 1.18 | ..... |
| ..... | ..... | ..... | *13.62* | ..... | ..... | ..... | *7.70* | ..... | *7.70* | ..... | *1.50* | ..... |
| 7253 | ..... | ..... | ..... | ..... | ..... | ..... | 13.47 | ..... | 13.47 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.50* | ..... | *13.50* | ..... | ..... | ..... |
| 7252 | ..... | ..... | **5.65** | ..... | ..... | ..... | 10.43 | ..... | 10.43 | ..... | ..... | ..... |
| ..... | ..... | ..... | *7.00* | ..... | ..... | ..... | *9.75* | ..... | *9.75* | ..... | ..... | ..... |
| 7347 | ..... | ..... | **7.30** | ..... | ..... | ..... | 8.26 | ..... | **8 26** | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.90* | ..... | ..... | ..... | *8.85* | ..... | *8.85* | ..... | ..... | ..... |
| 7214 | ..... | ..... | 4.40 | ..... | ..... | 0.50 | 1.50 | ..... | 2.00 | ..... | 0.79 | ..... |
| ..... | ..... | ..... | *4.00* | *Bn, Super, G* | *2.00* | ..... | ..... | *Bl, Bn, G, T* | *2.00* | ..... | *1.00* | ..... |

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Fruit Growers Supply Co., Los Angeles, Cal.** | | |
| 7315* | Tankage | W. McKinley, Rialto | 46.94 |
| | *Guaranteed* | | *47.98* |
| 7322* | Tankage | P. A. Demens, Alta Loma | 50.42 |
| | *Guaranteed* | | *51.52* |
| 7343* | Tankage (Fish) | Chas. H. Low, Riverside | **53.08** |
| | *Guaranteed* | | *56.16* |
| 7349* | Tankage (Fish) | C. W. Rhodes, et al. Pasadena | 54.78 |
| | *Guaranteed* | | *54.55* |
| 7348* | Tankage | Highland Oragne Assn., Highland | 51.72 |
| | *Guaranteed* | | *52.58* |
| | **General Fertilizer Assn., San Bernardino, Cal.** | | |
| 7257* | Fish Meal | Manufacturer's Warehouse | **55.34** |
| | *Guaranteed* | | *58.24* |
| 7282 | G. F. A. Special | W. F. Grove, Highland | **25.36** |
| 7283 | G. F. A. Special | W. F. Grove, Highland | **30.52** |
| | *Guaranteed* | | *33.60* |
| 7087 | G. F. A. Special | J. Henry Reynolds, Redlands | **29.34** |
| | *Guaranteed* | | *34.20* |
| 7088 | G. F. A. Special No. 2 | J. Henry Reynolds, Redlands | 28.96 |
| | *Guaranteed* | | *31.20* |
| 7258 | G. F. A. Special | Manufacturer's Warehouse | 45.09 |
| | *Guaranteed* | | *42.40* |
| 7259 | G. F. A. Special | Manufacturer's Warehouse | 29.30 |
| | *Guaranteed* | | *28.80* |
| 7086 | Nitrate of Soda | J. Henry Reynolds, Redlands | 76.22 |
| 7256 | Nitrate of Soda | Manufacturer's Warehouse | 75.65 |
| | *Guaranteed* | | *72.00* |
| 7080 | Special Mixture | J. Henry Reynolds, Redlands | 37.92 |
| | *Guaranteed* | | *38.00* |
| 7081 | Special Mixture | J. Henry Reynolds, Redlands | 34.09 |
| 7225 | Special Mixture | Factory at Ontario | 36.49 |
| | *Guaranteed* | | *34.20* |
| 7226 | Special Mixture | Factory at Ontario | 34.81 |
| | *Guaranteed* | | *34.20* |
| 7344 | Special Mixture | L. V. W. Brown, Riverside | 29.74 |
| | *Guaranteed* | | *31.20* |
| | **Germain Seed & Plant Co., Los Angeles, Cal.** | | |
| 7272 | Nitrate of Soda | Morris & Snow Seed Co., Los Angeles | 73.54 |
| | *Guaranteed* | | *72.00* |
| | **Globe Grain & Milling Co., Los Angeles, Cal.** | | |
| 7149 | Blood | G. A. Hanson Fruit Co., Upland | 67.03 |
| | *Guaranteed* | | *67.60* |
| 7269 | Blood | Manufacturer's Warehouse | 55.74 |
| | *Guaranteed* | | *53.80* |
| 7323 | Blood | M. C. Mascart, Redlands | **55 22** |
| | *Guaranteed* | | *57.20* |
| 7148* | Bone Meal | G. A. Hanson Fruit Co., Upland | 46.46 |
| 7216* | Bone Meal | Ulery & Son., Pomona | 48.34 |
| 7227* | Bone Meal | H. A. Schreiner, Fullerton | 45.67 |
| | *Guaranteed* | | *43.20* |
| 7147* | Whale Bone Meal | G. A. Hanson Fruit Co., Upland | 48.07 |
| | *Guaranteed* | | *45.60* |
| 7270 | Nitrate of Soda | Manufacturer's Warehouse | 74.69 |
| | *Guaranteed* | | *72.00* |
| 7217 | Superphosphate | Ulery & Son, Pomona | 23.26 |
| | *Guaranteed* | | *20.40* |
| 7150* | Tankage | G. A. Hanson Fruit Co., Upland | 44.00 |
| | *Guaranteed* | | *43.80* |
| 7215* | Tankage | Ulery & Son., Pomona | 52.08 |
| 7228* | Tankage | H. A. Schreiner, Fullerton | 48.70 |
| | *Guaranteed* | | *43.20* |

*7315—73% fine.
*7322—66% fine.
*7343—50% fine.
*7349—64% fine.
*7348—58% fine.
*7257—61% fine.
*7148—58% fine.
*7216—60% fine.
*7427—56% fine.
*7147—58% fine.
*7150—71% fine.
*7215—63% fine.
*7228—66% fine.

| Lab. No. | Phosphoric Acid: Available | Phosphoric Acid: Insoluble | Phosphoric Acid: Total | Phosphoric Acid: Guaranteed as derived from | Nitrogen: In Nitrates | Nitrogen: In Ammonia Salts | Nitrogen: Organic | Nitrogen: Organic Nitrogen Guaranteed as derived from | Nitrogen: Total | Potash: From Sulfate | Potash: Total | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7315 | ..... | ..... | 11.00 | ..... | ..... | ..... | 7.03 | ..... | **7.03** | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.50* | ..... | ..... | ..... | *7.37* | ..... | *7.37* | ..... | ..... | ..... |
| 7322 | ..... | ..... | **14.10** | ..... | ..... | ..... | 6.98 | ..... | 6.98 | ..... | ..... | ..... |
| ..... | ..... | ..... | *15.14* | ..... | ..... | ..... | *7.01* | ..... | *7.01* | ..... | ..... | ..... |
| 7343 | ..... | ..... | 7.55 | ..... | ..... | ..... | 9.17 | ..... | **9.17** | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *9.70* | ..... | *9.70* | ..... | ..... | ..... |
| 7349 | ..... | ..... | 8.45 | ..... | ..... | ..... | 9.30 | ..... | 9.30 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.78* | ..... | ..... | ..... | *9.17* | ..... | *9.17* | ..... | ..... | ..... |
| 7348 | ..... | ..... | 14.10 | ..... | ..... | ..... | 7.25 | ..... | 7.25 | ..... | ..... | ..... |
| ..... | ..... | ..... | *14.70* | ..... | ..... | ..... | *7.28* | ..... | *7.28* | ..... | ..... | ..... |
| 7257 | ..... | ..... | 7.80 | ..... | ..... | ..... | 9.58 | ..... | **9.58** | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.50* | ..... | ..... | ..... | *10.00* | ..... | *10.00* | ..... | ..... | ..... |
| 7282 | ..... | ..... | **7.05** | ..... | 1.57 | ..... | 1.95 | ..... | **3.52** | ..... | ..... | ..... |
| 7283 | ..... | ..... | **6.95** | ..... | 1.90 | ..... | 2.72 | ..... | 4.62 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | *Bn, G* | ..... | ..... | *4.50* | *Bn, G, T* | *4.50* | ..... | ..... | ..... |
| 7087 | ..... | ..... | 9.80 | ..... | 1.09 | ..... | 2.14 | ..... | **3.23** | ..... | 1.04 | ..... |
| ..... | ..... | ..... | *10.00* | *Bn. G* | *1.00* | ..... | *3.00* | *Bl, Bn, G* | *4.00* | ..... | *1.50* | ..... |
| 7088 | 4.27 | 7.58 | 11.85 | ..... | 0.51 | ..... | 2.56 | ..... | **3.07** | ..... | 0.65 | ..... |
| ..... | *5.00* | *5.00* | *10.00* | *Bn, G* | *1.00* | ..... | *3.00* | *Bl, Bn, G* | *4.00* | ..... | *1.00* | ..... |
| 7258 | 7.30 | 8.70 | 16.00 | ..... | 1.52 | ..... | 2.79 | ..... | **4.31** | ..... | 2.60 | 1.65 |
| ..... | *8.00* | *4.00* | *12.00* | *Bn, Super* | *1.50* | ..... | *3.50* | *Bl, Bn* | *5.00* | *2.00* | ..... | ..... |
| 7259 | **3.50** | 9.00 | 12.50 | ..... | 0.50 | ..... | 2.48 | ..... | 2.98 | ..... | 0.87 | ..... |
| ..... | *8.00* | *4.00* | *12.00* | *Bn, G* | *1.00* | ..... | *2.00* | *Bl, Bn, G* | *3.00* | ..... | *1.00* | ..... |
| 7086 | ..... | ..... | ..... | ..... | 15.88 | ..... | ..... | ..... | 15.88 | ..... | ..... | ..... |
| 7256 | ..... | ..... | ..... | ..... | 15.76 | ..... | ..... | ..... | 15.76 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... |
| 7080 | ..... | ..... | 10.90 | ..... | ..... | 2.11 | 2.57 | ..... | **4.68** | ..... | 1.19 | 0.75 |
| ..... | ..... | ..... | *10.00* | ..... | ..... | *3.00* | *2.00* | *Bl, Bn, T* | *5.00* | ..... | *1.00* | ..... |
| 7081 | ..... | ..... | 10.70 | ..... | ..... | 1.82 | 2.04 | ..... | 3.86 | ..... | **1.36** | 1.05 |
| 7225 | ..... | ..... | 11.60 | ..... | ..... | 1.73 | 2.21 | ..... | 3.94 | ..... | 1.83 | 0.75 |
| ..... | ..... | ..... | *10.00* | *Bn, T* | ..... | *2.00* | *2.00* | *Bl, Bn, T* | *4.00* | ..... | *1.50* | ..... |
| 7226 | ..... | ..... | 10.70 | ..... | 1.39 | 0.50 | 1.95 | *Sheep Manure* ..... | 3.84 | ..... | 1.77 | 0.70 |
| ..... | ..... | ..... | *10.00* | *Bn, T* | *1.50* | *0.50* | *2.00* | *Bl, Bn, T* | *4.00* | ..... | *1.50* | ..... |
| 7344 | ..... | ..... | 10.90 | ..... | ..... | 0.89 | 2.58 | *Sheep Manure* ..... | **3.47** | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | ..... | ..... | ..... | *4.00* | *Bl, Bn, T* | *4.00* | ..... | ..... | ..... |
| 7272 | ..... | ..... | ..... | ..... | 15.32 | ..... | ..... | ..... | 15.32 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... |
| 7149 | ..... | ..... | ..... | ..... | ..... | ..... | 12.89 | ..... | 12.89 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.00* | ..... | *13.00* | ..... | ..... | ..... |
| 7269 | ..... | ..... | 1.30 | ..... | ..... | ..... | 10.72 | ..... | 10.72 | ..... | ..... | ..... |
| ..... | ..... | ..... | *2.00* | ..... | ..... | ..... | *10.25* | ..... | *10.25* | ..... | ..... | ..... |
| 7323 | ..... | ..... | ..... | ..... | ..... | ..... | 10.62 | ..... | **10.62** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *11.00* | ..... | *11.00* | ..... | ..... | ..... |
| 7148 | ..... | ..... | 24.60 | ..... | ..... | ..... | 3.53 | ..... | 3.53 | ..... | ..... | ..... |
| 7216 | ..... | ..... | 26.00 | ..... | ..... | ..... | 3.57 | ..... | 3.57 | ..... | ..... | ..... |
| 7227 | ..... | ..... | 24.30 | ..... | ..... | ..... | 3.44 | ..... | 3.44 | ..... | ..... | ..... |
| ..... | ..... | ..... | *24.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 7147 | ..... | ..... | 26.70 | ..... | ..... | ..... | 3.34 | ..... | 3.34 | ..... | ..... | ..... |
| ..... | ..... | ..... | *26.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 7270 | ..... | ..... | ..... | ..... | 15.56 | ..... | ..... | ..... | 15.56 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... | *15.00* | ..... | ..... | ..... |
| 7217 | 18.72 | 0.58 | 19.30 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | ..... | ..... | *17.00* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 7150 | ..... | ..... | 7.35 | ..... | ..... | ..... | 7.33 | ..... | 7.33 | ..... | ..... | ..... |
| ..... | ..... | ..... | *6.50* | ..... | ..... | ..... | *7.50* | ..... | *7.50* | ..... | ..... | ..... |
| 7215 | ..... | ..... | 17.80 | ..... | ..... | ..... | 6.40 | ..... | 6.40 | ..... | ..... | ..... |
| 7228 | ..... | ..... | 17.50 | ..... | ..... | ..... | 5.77 | ..... | 5.77 | ..... | ..... | ..... |
| ..... | ..... | ..... | *18.00* | ..... | ..... | ..... | *4.50* | ..... | *4.50* | ..... | ..... | ..... |

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Hauser Packing Co., Los Angeles, Cal.** | | |
| 7196 | Bat Guano, High Grade | G. W. Fuhr, Azusa | **49.13** |
| | *Guaranteed* | | *61.44* |
| 7197 | Bat Guano, Low Grade | G. W. Fuhr, Azusa | 35.59 |
| | *Guaranteed* | | *44.74* |
| 7337 | Bat Guano | G. W. Fuhr, Azusa | **46.57** |
| | *Guaranteed* | | *61.72* |
| 7195* | Bone Meal | G. W. Fuhr, Azusa | 46.18 |
| | *Guaranteed* | | *45.60* |
| 7209* | Bone Meal | W. D. Richards, Corona | 49.34 |
| | *Guaranteed* | | *42.48* |
| 7265* | Bone Meal | Thomas Chisholm, Pasadena | 49.30 |
| | *Guaranteed* | | *46.80* |
| 7254* | Fish Meal | H. Umemoto, Los Angeles | **41 50** |
| | *Guaranteed* | | *50.40* |
| 7059* | Tankage | William P. Book, Covina | 52 94 |
| 7061* | Tankage | R. H. Eddington, Azusa | **49 07** |
| 7297* | Tankage | Stewart Citrus Assn., Upland | 51.34 |
| 7298* | Tankage | Stewart Citrus Assn., Upland | 50.92 |
| 7318* | Tankage | J. S. Grepe, East Highlands | 53.75 |
| 7326 | Tankage | J. C. Boyd, Rialto | 51.38 |
| | *Guaranteed* | | *52.80* |
| 7190* | Tankage | E. F. Wolever, Highgrove | 45 42 |
| 7192* | Tankage | C. A. Griffith, Azusa | 45.88 |
| 7193* | Tankage | G. W. Fuhr, Azusa | 47.21 |
| 7305* | Tankage | Alex. Keating, Redlands | 45.80 |
| 7339* | Tankage | C. Menefee, Covina | 48.26 |
| | *Guaranteed* | | *48.00* |
| 7285* | Tankage | B. W. Barnhart, Pomona | 46.32 |
| | *Guaranteed* | | *48.00* |
| 7291* | Tankage | Stewart Citrus Assn., Upland | 42 02 |
| 7292* | Tankage | Stewart Citrus Assn., Upland | 42.06 |
| 7293* | Tankage | Stewart Citrus Assn., Upland | 43.31 |
| 7294* | Tankage | Stewart Citrus Assn., Upland | 43.02 |
| 7295* | Tankage | Stewart Citrus Assn., Upland | 41.00 |
| 7296* | Tankage | Stewart Citrus Assn., Upland | 41.88 |
| | *Guaranteed* | | *43.20* |
| 7300* | Tankage | H. J. Nichols, Pomona | 46.98 |
| 7338* | Tankage | Mrs. J. M. Riley, Los Angeles | 45.50 |
| | *Guaranteed* | | *45.92* |
| 7290* | Tankage | H. C. Meek, Upland | 46.76 |
| | *Guaranteed* | | *47.45* |
| 7299* | Tankage | C. F. Lawrence, Claremont | 46.44 |
| | *Guaranteed* | | *47.46* |
| 7313* | Tankage | East Highlands Citrus Assn., East Highlands | 43.81 |
| | *Guaranteed* | | *44.40* |
| 7314* | Tankage | W. B. Bayless, Los Angeles | 42.70 |
| | *Guaranteed* | | *40.80* |
| 7321* | Tankage | Citrus Fruit Assn., Ontario | 47.48 |
| | *Guaranteed* | | *47.40* |
| 7329* | Tankage | H. Dameral, et al, Covina | 43.81 |
| | *Guaranteed* | | *44.40* |
| 7331* | Tankage | Monte Vista Citrus Assn., Riverside | 43 44 |
| | *Guaranteed* | | *45.24* |
| 7358* | Tankage | R. T. Nelson, Upland | 46.62 |
| | *Guaranteed* | | *46.50* |
| 7194 | Special Mixture | G. W. Fuhr, Azusa | 50.23 |
| | *Guaranteed* | | *49.20* |
| | **Oakland Meat & Packing Co., Emeryville, Cal.** | | |
| 7174* | Tankage | B. L. Byer, Upland | 48.86 |
| | *Guaranteed* | | *48.79* |
| 7175* | Tankage | B. L. Byer, Upland | 47.40 |
| | *Guaranteed* | | *46.79* |
| 7206* | Tankage | S. Miyamoto, Berkeley | 44.26 |
| | *Guaranteed* | | *37.20* |
| 7336* | Tankage | C. W. McIntosh, Rialto | 45.86 |
| | *Guaranteed* | | *47.99* |

*7195—51% fine. *7209—53% fine. *7265—51% fine. *7254—63% fine. *7059—73% fine. *7061—74% fine. *7297—79% fine. *7298—76% fine. *7318—73% fine. *7190—80% fine. *7192—81% fine. *7193—73% fine. Some Hoof. *7305—69% fine. *7339—68% fine. *7285—75% fine. *7291—72% fine. *7292—76% fine. *7293—73% fine.

| Lab. No. | Phosphoric Acid: Available | Phosphoric Acid: Insoluble | Phosphoric Acid: Total | Phosphoric Acid: Guaranteed as derived from | Nitrogen: In Nitrates | Nitrogen: In Ammonia Salts | Nitrogen: Organic | Nitrogen: Organic Nitrogen Guaranteed as derived from | Nitrogen: Total | Potash: From Sulfate | Potash: Total | Chlorin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7196 | ..... | ..... | 5.65 | ..... | 1.64 | 1.30 | 4.35 | ..... | **7.29** | ..... | 3.68 | ..... |
| ..... | ..... | ..... | *5.60* | ..... | ..... | ..... | *10.40* | ..... | *10.40* | ..... | *2.40* | ..... |
| 7197 | ..... | ..... | 6.90 | ..... | 0.22 | 1.09 | 3.90 | ..... | 5.21 | ..... | 1.15 | ..... |
| ..... | ..... | ..... | *8.40* | ..... | ..... | ..... | *5.00* | ..... | *5.00* | ..... | *0.33* | ..... |
| 7337 | ..... | ..... | 8.35 | ..... | ..... | 0.82 | 6.24 | ..... | **7.06** | ..... | **1.33** | ..... |
| ..... | ..... | ..... | *5.60* | ..... | ..... | ..... | *10.50* | ..... | *10.50* | ..... | *2.30* | ..... |
| 7195 | ..... | ..... | **22.60** | ..... | ..... | ..... | 3.97 | ..... | 3.97 | ..... | ..... | ..... |
| ..... | ..... | ..... | *26.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 7209 | ..... | ..... | 27.80 | ..... | ..... | ..... | 3.33 | ..... | 3.33 | ..... | ..... | ..... |
| ..... | ..... | ..... | *27.00* | ..... | ..... | ..... | *2.10* | ..... | *2.10* | ..... | ..... | ..... |
| 7265 | ..... | ..... | 27.60 | ..... | ..... | ..... | 3.37 | ..... | 3.37 | ..... | ..... | ..... |
| ..... | ..... | ..... | *27.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 7254 | ..... | ..... | 7.35 | ..... | ..... | ..... | 6.81 | ..... | **6.81** | ..... | ..... | ..... |
| ..... | ..... | ..... | *6.00* | ..... | ..... | ..... | *9.00* | ..... | *9.00* | ..... | ..... | ..... |
| 7059 | ..... | ..... | 5.80 | ..... | ..... | ..... | 9.58 | ..... | **9.58** | ..... | ..... | ..... |
| 7061 | ..... | ..... | 6.45 | ..... | ..... | ..... | 8.61 | ..... | **8.61** | ..... | ..... | ..... |
| 7297 | ..... | ..... | 3.70 | ..... | ..... | ..... | 9.77 | ..... | 9.77 | ..... | ..... | ..... |
| 7298 | ..... | ..... | 3.75 | ..... | ..... | ..... | 9.67 | ..... | **9.67** | ..... | ..... | ..... |
| 7318 | ..... | ..... | 4.15 | ..... | ..... | 2.21 | 7.95 | ..... | 10.16 | ..... | ..... | ..... |
| 7326 | ..... | ..... | 4.50 | ..... | ..... | 1.42 | 8.16 | ..... | **9.58** | ..... | ..... | ..... |
| ..... | ..... | ..... | *4.00* | ..... | ..... | ..... | *10.00* | ..... | *10.00* | ..... | ..... | ..... |
| 7190 | ..... | ..... | 10.05 | ..... | ..... | ..... | 6.95 | ..... | **6.95** | ..... | ..... | ..... |
| 7192 | ..... | ..... | 8.35 | ..... | ..... | ..... | 7.47 | ..... | **7.47** | ..... | ..... | ..... |
| 7193 | ..... | ..... | 9.50 | ..... | ..... | ..... | 7.46 | ..... | **7.46** | ..... | ..... | ..... |
| 7305 | ..... | ..... | 9.25 | ..... | ..... | ..... | 7.23 | ..... | **7.23** | ..... | ..... | ..... |
| 7339 | ..... | ..... | 8.30 | ..... | ..... | ..... | 7.98 | ..... | 7.98 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *8.00* | ..... | *8.00* | ..... | ..... | ..... |
| 7285 | ..... | ..... | 10.60 | ..... | ..... | ..... | 7.00 | ..... | **7.00** | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | ..... | ..... | ..... | *7.50* | ..... | *7.50* | ..... | ..... | ..... |
| 7291 | ..... | ..... | 11.30 | ..... | ..... | ..... | 5.93 | ..... | 5.93 | ..... | ..... | ..... |
| 7292 | ..... | ..... | 11.45 | ..... | ..... | ..... | 5.90 | ..... | 5.90 | ..... | ..... | ..... |
| 7293 | ..... | ..... | 11.25 | ..... | ..... | ..... | 6.21 | ..... | 6.21 | ..... | ..... | ..... |
| 7294 | ..... | ..... | 11.05 | ..... | ..... | ..... | 6.20 | ..... | 6.20 | ..... | ..... | ..... |
| 7295 | ..... | ..... | 11.05 | ..... | ..... | ..... | 5.78 | ..... | 5.78 | ..... | ..... | ..... |
| 7296 | ..... | ..... | 11.50 | ..... | ..... | ..... | 5.85 | ..... | 5.85 | ..... | ..... | ..... |
| ..... | ..... | ..... | *12.00* | ..... | ..... | ..... | *6.00* | ..... | *6.00* | ..... | ..... | ..... |
| 7300 | ..... | ..... | 9.75 | ..... | ..... | ..... | 7.35 | ..... | 7.35 | ..... | ..... | ..... |
| 7338 | ..... | ..... | 9.40 | ..... | ..... | ..... | 7.13 | ..... | 7.13 | ..... | ..... | ..... |
| ..... | ..... | ..... | *9.55* | ..... | ..... | ..... | *7.18* | ..... | *7.18* | ..... | ..... | ..... |
| 7290 | ..... | ..... | 9.45 | ..... | ..... | ..... | 7.38 | ..... | 7.38 | ..... | ..... | ..... |
| ..... | ..... | ..... | *9.46* | ..... | ..... | ..... | *7.52* | ..... | *7.52* | ..... | ..... | ..... |
| 7299 | ..... | ..... | 9.50 | ..... | ..... | ..... | 7.30 | ..... | 7.30 | ..... | ..... | ..... |
| ..... | ..... | ..... | *9.83* | ..... | ..... | ..... | *7.43* | ..... | *7.43* | ..... | ..... | ..... |
| 7313 | ..... | ..... | 12.35 | ..... | ..... | ..... | 6.04 | ..... | 6.04 | ..... | ..... | ..... |
| ..... | ..... | ..... | *13.00* | ..... | ..... | ..... | *6.00* | ..... | *6.00* | ..... | ..... | ..... |
| 7314 | ..... | ..... | 10.70 | ..... | ..... | ..... | 6.22 | ..... | 6.22 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | ..... | ..... | ..... | *6.00* | ..... | *6.00* | ..... | ..... | ..... |
| 7321 | ..... | ..... | 9.05 | ..... | ..... | ..... | 7.63 | ..... | 7.63 | ..... | ..... | ..... |
| ..... | ..... | ..... | *9.50* | ..... | ..... | ..... | *7.50* | ..... | *7.50* | ..... | ..... | ..... |
| 7329 | ..... | ..... | 6.15 | ..... | ..... | ..... | 7.59 | ..... | **7.59** | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.00* | ..... | ..... | ..... | *8.00* | ..... | *8.00* | ..... | ..... | ..... |
| 7331 | ..... | ..... | 9.40 | ..... | ..... | ..... | 6.70 | ..... | **6.70** | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.50* | ..... | ..... | ..... | *7.30* | ..... | *7.30* | ..... | ..... | ..... |
| 7358 | ..... | ..... | 10.85 | ..... | ..... | ..... | 7.00 | ..... | 7.00 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.75* | ..... | ..... | ..... | *7.50* | ..... | *7.50* | ..... | ..... | ..... |
| 7194 | 3.30 | 2.00 | 5.30 | ..... | 8.53 | ..... | 0.61 | ..... | 9.14 | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.00* | *Super, T* | ..... | ..... | *9.00* | *Bl, Bn, T* | *9.00* | ..... | ..... | ..... |
| 7174 | ..... | ..... | 16.40 | ..... | ..... | ..... | 6.08 | ..... | 6.08 | ..... | ..... | ..... |
| ..... | ..... | ..... | *16.34* | ..... | ..... | ..... | *6.08* | ..... | *6.08* | ..... | ..... | ..... |
| 7175 | ..... | ..... | 15.70 | ..... | ..... | ..... | 5.95 | ..... | 5.95 | ..... | ..... | ..... |
| ..... | ..... | ..... | *15.63* | ..... | ..... | ..... | *5.84* | ..... | *5.84* | ..... | ..... | ..... |
| 7206 | ..... | ..... | 4.60 | ..... | ..... | ..... | 8.07 | ..... | 8.07 | ..... | ..... | ..... |
| ..... | ..... | ..... | *3.00* | ..... | ..... | ..... | *7.00* | ..... | *7.00* | ..... | ..... | ..... |
| 7336 | ..... | ..... | **15.50** | ..... | ..... | ..... | 5.68 | ..... | 5.68 | ..... | ..... | ..... |
| ..... | ..... | ..... | *16.63* | ..... | ..... | ..... | *5.84* | ..... | *5.84* | ..... | ..... | ..... |

*7294—73% fine.
*7295—74% fine.
*7296—72% fine.
*7300—74% fine.
*7338—71% fine.
*7290—72% fine.

*7299—70% fine.
*7313—65% fine.
*7314—61% fine.
*7321—71% fine.
*7329—68% fine.
*7331—76% fine.

*7358—75% fine.
*7174—64% fine. Some Hoof.
*7175—70% fine. Some Hoof.
*7206—58% fine.
*7336—66% fine. Some Hoof.

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Pacific Bone Coal and Fertilizing Co., San Francisco, Cal.** | | |
| 7273* | Bone Meal | Curtis Ranch Co., Bloomington | 45.30 |
| 7274* | Bone Meal | Curtis Ranch Co., Bloomington | 45.34 |
| | *Guaranteed* | | *45.20* |
| 7105* | Steamed Bone and Blood | C. Huber, Los Angeles | 48.72 |
| | *Guaranteed* | | *48.00* |
| 7157 | Special | P. A. Demens, Alta Loma | 32.25 |
| | *Guaranteed* | | *35.20* |
| 7350 | Special | Anaheim Citrus Fruit Co., Anaheim | 37.06 |
| | *Guaranteed* | | *36.00* |
| 7280 | Sulfate of Ammonia | La Verne Orange and Lemon Growers Assn., Lordsburg | 98.88 |
| | *Guaranteed* | | *98.70* |
| | **Pacific Guano & Fertilizer Co., San Francisco, Cal.** | | |
| 7169 | Bat Guano (Armour's) | S. E. Bryant, Covina | 71.18 |
| | *Guaranteed* | | *71.66* |
| 7316 | Bat Guano | E. R. Brubaker, Azusa | 67.95 |
| | *Guaranteed* | | *62.11* |
| 7317 | Bat Guano | Mrs. O. F. Wright, Azusa | 54.30 |
| | *Guaranteed* | | *52.09* |
| 7108 | Blood | A. G. Johnson, Redlands | 71.66 |
| | *Guaranteed* | | *73.37* |
| 7162 | Blood (Armour's) | A. M. Seeley, Covina | 71.55 |
| | *Guaranteed* | | *72.02* |
| 7210 | Blood (Armour's) | John Blake, Pasadena | 70.25 |
| | *Guaranteed* | | *70.98* |
| 7219 | Blood | Wilson & Hickox, Upland | 70.67 |
| | *Guaranteed* | | *69.99* |
| 7160* | Bone Meal (Armour's) | E. F. Wilson, Upland | 49.08 |
| 7222* | Bone Meal (Armour's) | E. F. Wilson, Upland | 48.14 |
| | *Guaranteed* | | *45.20* |
| 7161* | Bone Flour | R. M. Douglas, Covina | 43.56 |
| | *Guaranteed* | | *43.01* |
| 7166* | Bone Meal (Armour's) | A. M. Seeley, Covina | 48.07 |
| 7231* | Bone Meal (Armour's) | Highland Fruit Growers Assn., Highland | 46.97 |
| 7238* | Bone Meal (Armour's) | E. M. Hudson, Los Angeles | 46.82 |
| | *Guaranteed* | | *45.60* |
| 7189* | Bone Meal | Wilson & Hickox, Upland | 46.70 |
| | *Guaranteed* | | *44.16* |
| 7211* | Bone Meal (Armour's) | John Blake, Pasadena | 45.70 |
| | *Guaranteed* | | *45.36* |
| 7220* | Bone Flour | Wilson & Hickox, Upland | 44.28 |
| | *Guaranteed* | | *43.68* |
| 7237* | Bone Meal (Armour's) | E. M. Hudson, Los Angeles | 45.50 |
| | *Guaranteed* | | *46.02* |
| 7168 | Special Cropmaker (Armour's) | A. M. Seeley, Covina | 38.75 |
| 7202 | Special Cropmaker (Armour's) | F. F. Struve, Pomona | 38.72 |
| | *Guaranteed* | | *35.20* |
| 7203 | Special Cropmaker | E. F. Struve, Pomona | 37.19 |
| 7212 | Special Cropmaker | John Blake, Pasadena | 34.99 |
| 7234 | Special Cropmaker | Highland Fruit Growers Assn., Highland | 34.93 |
| 7311 | Special Cropmaker | Johnson & Fairchild, Redlands | 33.65 |
| 7312 | Special Cropmaker | Johnson & Fairchild, Redlands | 35.54 |
| | *Guaranteed* | | *33.20* |
| 7319* | Special Cropmaker | Mrs. S. F. McDonald, Glendora | 44.82 |
| | *Guaranteed* | | *43.60* |
| 7180 | Diamond N | S. Schaffner, Upland | 35.94 |
| | *Guaranteed* | | *34.00* |

*7273—56% fine.
*7274—54% fine.
*7105—48% fine as bone.
*7160—41% fine.
*7222—41% fine.
*7161—98% fine.
*7166—53% fine.
*7231—61% fine.
*7238—53% fine.
*7189—50% fine.
*7211—69% fine.
*7220—99% fine.
*7237—68% fine.
*7319—Brand name does not conform to composition. Agreed by all parties that mistake is made in tagging. Present guarantee inserted by Fertilizer Control.

| | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab. No. | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen Guaranteed as derived from | Total | From Sulfate | Total | Chlorin |
| 7273 | ..... | ..... | 24.00 | ..... | ..... | ..... | 3.45 | ..... | 3.45 | ..... | ..... | ..... |
| 7274 | ..... | ..... | 23.70 | ..... | ..... | ..... | 3.48 | ..... | 3.48 | ..... | ..... | ..... |
| ..... | ..... | ..... | *24.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 7105 | ..... | ..... | 21.00 | ..... | ..... | ..... | 4.90 | ..... | 4.90 | ..... | ..... | ..... |
| ..... | ..... | ..... | *20.00* | ..... | ..... | ..... | *5.00* | ..... | *5.00* | ..... | ..... | ..... |
| 7157 | ..... | ..... | 10.80 | ..... | 0.17 | 0.57 | 2.52 | ..... | **3.26** | 1.82 | ..... | 0.67 |
| ..... | ..... | ..... | *10.00* | *Bn* | ..... | ..... | *4.00* | *Bl, Bn, T* | *4.00* | *2.00* | ..... | ..... |
| 7350 | 5.28 | 4.92 | 10.20 | ..... | 1.67 | 1.56 | 1.94 | ..... | 5.17 | ..... | ..... | ..... |
| ..... | *3.00* | *7.00* | *10.00* | *Bat G, Bn, Super* | *1.50* | *1.50* | *2.00* | *Bat G, Bl, Bn, T* | *5.00* | ..... | ..... | ..... |
| 7280 | ..... | ..... | ..... | ..... | ..... | ..... | 20.60 | ..... | 20.60 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *20.50* | ..... | *20.50* | ..... | ..... | ..... |
| 7169 | ..... | ..... | 4.70 | ..... | 0.38 | 2.47 | 10.05 | ..... | **12.90** | ..... | 1.81 | ..... |
| ..... | ..... | ..... | *4.00* | ..... | ..... | ..... | *13.20* | ..... | *13.20* | ..... | *1.75* | ..... |
| 7316 | ..... | ..... | 3.25 | ..... | ..... | 1.50 | 11.21 | ..... | 12.71 | ..... | 1.52 | ..... |
| ..... | ..... | ..... | *3.03* | ..... | ..... | ..... | *11.62* | ..... | *11.62* | ..... | *1.35* | ..... |
| 7317 | ..... | ..... | 4.20 | ..... | 0.52 | 1.55 | 7.35 | ..... | 9.42 | ..... | 2.02 | ..... |
| ..... | ..... | ..... | *4.31* | ..... | ..... | ..... | *8.80* | ..... | *8.80* | ..... | *2.34* | ..... |
| 7108 | ..... | ..... | ..... | ..... | ..... | ..... | 13.78 | ..... | **13.78** | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *14.11* | ..... | *14.11* | ..... | ..... | ..... |
| 7162 | ..... | ..... | ..... | ..... | ..... | ..... | 13.76 | ..... | 13.76 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.85* | ..... | *13.85* | ..... | ..... | ..... |
| 7210 | ..... | ..... | ..... | ..... | ..... | ..... | 13.51 | ..... | 13.51 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.65* | ..... | *13.65* | ..... | ..... | ..... |
| 7219 | ..... | ..... | ..... | ..... | ..... | ..... | 13.59 | ..... | 13.59 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.46* | ..... | *13.46* | ..... | ..... | ..... |
| 7160 | ..... | ..... | 26.70 | ..... | ..... | ..... | 3.55 | ..... | 3.55 | ..... | ..... | ..... |
| 7222 | ..... | ..... | 26.20 | ..... | ..... | ..... | 3.48 | ..... | 3.48 | ..... | ..... | ..... |
| ..... | ..... | ..... | *24.95* | ..... | ..... | ..... | *3.18* | ..... | *3.18* | ..... | ..... | ..... |
| 7161 | ..... | ..... | 33.70 | ..... | ..... | ..... | 0.65 | ..... | 0.65 | ..... | ..... | ..... |
| ..... | ..... | ..... | *33.08* | ..... | ..... | ..... | *0.69* | ..... | *0.69* | ..... | ..... | ..... |
| 7166 | ..... | ..... | 26.90 | ..... | ..... | ..... | 3.29 | ..... | 3.29 | ..... | ..... | ..... |
| 7231 | ..... | ..... | 25.90 | ..... | ..... | ..... | 3.31 | ..... | 3.31 | ..... | ..... | ..... |
| 7238 | ..... | ..... | 26.30 | ..... | ..... | ..... | 3.18 | ..... | 3.18 | ..... | ..... | ..... |
| ..... | ..... | ..... | *26.00* | ..... | ..... | ..... | *3.00* | ..... | *3.00* | ..... | ..... | ..... |
| 7189 | ..... | ..... | 23.80 | ..... | ..... | ..... | 4.03 | ..... | 4.03 | ..... | ..... | ..... |
| ..... | ..... | ..... | *22.00* | ..... | ..... | ..... | *3.70* | ..... | *3.70* | ..... | ..... | ..... |
| 7211 | ..... | ..... | 29.00 | ..... | ..... | ..... | 2.27 | ..... | 2.27 | ..... | ..... | ..... |
| ..... | ..... | ..... | *28.00* | ..... | ..... | ..... | *2.45* | ..... | *2.45* | ..... | ..... | ..... |
| 7220 | ..... | ..... | 34.30 | ..... | ..... | ..... | 0.65 | ..... | 0.65 | ..... | ..... | ..... |
| ..... | ..... | ..... | *33.08* | ..... | ..... | ..... | *0.83* | ..... | *0.83* | ..... | ..... | ..... |
| 7237 | ..... | ..... | 29.40 | ..... | ..... | ..... | 2.13 | ..... | 2.13 | ..... | ..... | ..... |
| ..... | ..... | ..... | *28.75* | ..... | ..... | ..... | *2.40* | ..... | *2.40* | ..... | ..... | ..... |
| 7168 | **6.41** | 5.64 | 12.05 | ..... | 1.55 | ..... | 2.66 | ..... | 4.21 | 2.04 | ..... | 0.52 |
| 7202 | 7.55 | 3.70 | 11.25 | ..... | 1.43 | ..... | 2.57 | ..... | 4.00 | 3.01 | ..... | 0.75 |
| ..... | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *1.50* | ..... | *2.50* | *Bl, Bn, G, T* | *4.00* | *2.00* | ..... | ..... |
| 7203 | 5.35 | 5.50 | 10.85 | ..... | 0.70 | ..... | 3.76 | ..... | 4.46 | 1.38 | ..... | 0.70 |
| 7212 | 4.60 | 6.50 | 11.10 | ..... | ..... | ..... | 4.09 | ..... | 4.09 | 1.02 | ..... | 0.70 |
| 7234 | **4.84** | 5.66 | 10.50 | ..... | ..... | ..... | 4.19 | ..... | 4.19 | 1.11 | ..... | 0.77 |
| 7311 | 7.01 | 3.24 | 10.25 | ..... | 1.31 | ..... | 2.63 | ..... | 3.94 | 1.22 | ..... | 0.65 |
| 7312 | **5.89** | 4.76 | 10.65 | ..... | ..... | 0.48 | 3.77 | ..... | 4.25 | 1.18 | ..... | 0.97 |
| ..... | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | ..... | ..... | *4.00* | *Bn, Bl, G, T* | *4.00* | *1.00* | ..... | ..... |
| 7319 | ..... | ..... | 8.90 | ..... | 2.34 | ..... | 3.96 | ..... | 6.30 | ..... | 1.95 | 1.45 |
| ..... | ..... | ..... | *9.00* | *Bn, G, Super* | *2.00* | ..... | *4.00* | *Bl, Bn, G, T, Fs* | *6.00* | *2.00* | ..... | ..... |
| 7180 | 7.40 | 2.00 | 9.40 | ..... | 1.15 | ..... | 2.98 | ..... | 4.13 | 2.42 | ..... | 0.62 |
| ..... | *8.00* | *1.00* | *9.00* | *Bn, Super* | *1.00* | ..... | *3.00* | *Bl, Bn, Fs* | *4.00* | *2.00* | ..... | ..... |

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Pacific Guano & Fertilizer Co.,** (Continued.) **San Francisco, Cal.** | | |
| 7181 | Dimond S | Wilson & Hickox, Upland | 46.50 |
| | *Guaranteed* | | *45.60* |
| 7113 | Gaviota Special | A. G. Johnson, Redlands | 37.41 |
| | *Guaranteed* | | *34.20* |
| 7302 | Gaviota Special | H. Latimer, Ontario | 44.20 |
| 7303 | Gaviota Special | H. Latimer, Ontario | 44.52 |
| 7320* | Gaviota Special | Mrs. S. F. McDonald, Glendora | 45.07 |
| | *Guaranteed* | | *43.60* |
| 7327 | Gaviota Special | J. C. Boyd, Rialto | 31.13 |
| | *Guaranteed* | | *27.40* |
| 7185 | Gaviota Special 3–8–2 | Wilson & Hickox, Upland | 28.81 |
| 7200 | Gaviota Special 3–8–2 | E. F. Struve, Pomona | 31.23 |
| | *Guaranteed* | | *28.00* |
| 7186 | Gaviota Special 4–8–0 | Wilson & Hickox, Upland | 28.70 |
| | *Guaranteed* | | *28.80* |
| 7187 | Gaviota Special 2–11–5 | Wilson & Hickox, Upland | 34.97 |
| | *Guaranteed* | | *32.80* |
| 7198 | Gaviota Special 4–8–5 | E. F. Struve, Pomona | 41.62 |
| | *Guaranteed* | | *38.80* |
| 7199 | Gaviota Special 4–9–2 | E. F. Struve, Pomona | 35.93 |
| | *Guaranteed* | | *34.00* |
| 7204 | Gaviota Special 1.5–14–1.5 | E. F. Struve, Pomona | 29.02 |
| 7223 | Gaviota Special 1.5–14–1.5 | Wilson & Hickox, Upland | 27.28 |
| | *Guaranteed* | | *27.00* |
| 7159 | Special Lawn (Armour's) | E. F. Wilson, Upland | 34.22 |
| | *Guaranteed* | | *33.20* |
| 7213 | Special Lawn (Armour's) | John Blake, Pasadena | 26.76 |
| | *Guaranteed* | | *26.40* |
| 7240 | Special Lawn (Armour's) | E. M. Hudson, Los Angeles | 26.80 |
| | *Guaranteed* | | *26.40* |
| 7241 | Special Lawn (Armour's) | E. M. Hudson, Los Angeles | 25.36 |
| | *Guaranteed* | | *24.00* |
| 7242 | Special Lawn (Armour's) | E. M. Hudson, Los Angeles | 24.78 |
| | *Guaranteed* | | *24.00* |
| 7109 | Nitrate of Soda | A. G. Johnson, Redlands | 74.50 |
| 7182 | Nitrate of Soda | Wilson & Hickox, Upland | 73.54 |
| 7235 | Nitrate of Soda | E. M. Hudson, Los Angeles | 73.73 |
| | *Guaranteed* | | *72.00* |
| 7164* | Temporary P. N. K | A. M. Seeley, Covina | 37.58 |
| | *Guaranteed* | | *32.80* |
| 7165* | Temporary P. N. K | A. M. Seeley, Covina | 42.40 |
| | *Guaranteed* | | *38.80* |
| 7112 | Special | A. G. Johnson, Redlands | 36.88 |
| | *Guaranteed* | | *34.20* |
| 7183 | Special | Wilson & Hickox, Upland | 37.20 |
| 7201 | Special | E. F. Struve, Pomona | 38.33 |
| | *Guaranteed* | | *36.00* |
| 7184 | Special | Wilson & Hickox, Upland | 39.75 |
| | *Guaranteed* | | *35.20* |
| 7243 | Special (Armour's) | E. M. Hudson, Los Angeles | 24.19 |
| | *Guaranteed* | | *24.00* |
| 7158 | Special (Armour's) 4–10–1 | E. F. Wilson, Upland | 34.46 |
| 7167 | Special (Armour's) 4–10–1 | A. M. Seeley, Covina | 34.16 |
| 7233 | Special (Armour's) 4–10–1 | Highland Fruit Growers Assn., Highland | 35.74 |
| | *Guaranteed* | | *33.20* |
| 7232 | Special (Armour's) 4–10–1 | Highland Fruit Growers Assn., Highland | 35.48 |
| | *Guaranteed* | | *33.20* |
| 7239 | Special (Armour's) 4–10–1 | E. M. Hudson, Los Angeles | 34.12 |
| | *Guaranteed* | | *33.20* |
| 7205 | Superphosphate, Cresco | E. F. Struve, Pomona | 22.56 |
| | *Guaranteed* | | *21.60* |

*7320—Brand name does not conform to composition. Agreed by all parties that mistake is made in tagging. Present guarantee inserted by Fertilizer Control.

*7164 } The Brand P. N. K. calls for 6% potash. Owing to the dearth of this material the
*7165 } Fertilizer Control has authorized the reduction to 5% potash in goods marked Temporary.

| | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab. No. | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen Guaranteed as derived from | Total | From Sulfate | Total | Chlorin |
| 7181 | 8.28 | 0.52 | 8.80 | | 2.17 | | 4.35 | | 6.52 | 2.32 | | 0.55 |
| | *8.00* | *1.00* | *9.00* | *Bn, G, Super* | *2.00* | | *4.00* | *Bl, Bn, G, T, Fs* | *6.00* | *2.00* | | |
| 7113 | 8.56 | 2.54 | 11.10 | | 2.29 | | 2.73 | | 5.02 | 0.95 | | 0.80 |
| | | | *10.50* | *Bn, Super* | *1.50* | | *3.00* | *Fs, G* | *4.50* | *0.50* | | |
| 7302 | | | 8.80 | | 2.35 | | 3.63 | | 5.98 | | 2.47 | 1.32 |
| 7303 | | | 8.70 | | 2.26 | | 3.81 | | 6.07 | | 2.47 | 1.45 |
| 7320 | | | 8.75 | | 2.33 | | 4.06 | | 6.39 | | 1.95 | 1.22 |
| | | | *9.00* | *Bn, G, Super* | *2.00* | | *4.00* | *Bl, Bn, G, T, Fs* | *6.00* | *2.00* | | |
| 7327 | | | 9.95 | | 2.06 | | 1.50 | | 3.56 | | 1.05 | 0.67 |
| | | | *10.00* | *Bn, G, Super* | *1.50* | | *1.50* | *Bl, Bn, Fs* | *3.00* | | *0.50* | |
| 7185 | 6.65 | 1.50 | 8.15 | | 0.97 | | 2.09 | | 3.06 | 2.17 | | 0.72 |
| 7200 | 6.56 | 1.84 | 8.40 | | 0.95 | | 2.26 | | 3.21 | 2.87 | | 0.70 |
| | | | *8.00* | *G, Super* | *1.50* | | *1.50* | *Fs, G* | *3.00* | *2.00* | | |
| 7186 | 8.04 | 0.56 | 8.60 | | 3.04 | | 0.79 | | 3.83 | | | |
| | | | *8.00* | *Bn, G, Super* | *3.00* | | *1.00* | *Bl, Bn, G, T, Fs* | *4.00* | | | |
| 7187 | 6.07 | 5.38 | 11.45 | | | 0.66 | 1.68 | | 2.34 | 5.00 | | 0.57 |
| | | | *11.00* | *Bn, G, Super* | | | *2.00* | *Bl, Bn, G, T, Fs* | *2.00* | *5.00* | | |
| 7198 | 5.60 | 2.60 | 8.20 | | 2.23 | | 2.39 | | 4.62 | 4.80 | | 1.00 |
| | | | *8.00* | *Bn, G, Super* | *2.00* | | *2.00* | *Bl, Bn, G, T, Fs* | *4.00* | *5.00* | | |
| 7199 | 7.54 | 1.96 | 9.50 | | 3.35 | | 0.72 | | 4.07 | 2.50 | | 0.80 |
| | | | *9.00* | *Super* | *3.00* | | *1.00* | *Bl, Bn, G, T* | *4.00* | *2.00* | | |
| 7204 | 14.50 | 0.70 | 15.20 | | 1.20 | | 0.30 | | 1.50 | 1.29 | | |
| 7223 | 13.64 | 0.96 | 14.60 | | 1.13 | | 0.35 | | 1.48 | 1.33 | | |
| | *13.50* | *0.50* | *14.00* | *Bat G, Super* | *1.00* | | *0.50* | *Bat, G* | *1.50* | *1.50* | | |
| 7159 | **6.76** | 3.74 | 10.50 | | 1.94 | 1.10 | 0.78 | | 3.82 | 1.64 | | 0.52 |
| | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *2.00* | *1.00* | *1.00* | *Bl, Bn, G, T* | *4.00* | *1.00* | | |
| 7213 | **5.62** | 3.68 | 9.30 | | | | 3.25 | | 3.25 | | 0.62 | 1.02 |
| | *7.75* | *2.25* | *10.00* | *Bn, G, Super* | | | *3.00* | *Bl, Bn, G, T* | *3.00* | *0.50* | | |
| 7240 | **5.11** | 5.14 | 10.25 | | 1.57 | | 1.45 | | 3.02 | 0.59 | | 0.65 |
| | *7.50* | *2.50* | *10.00* | *Bn, G, Super* | *1.50* | | *1.50* | *Bl, Bn, G, T* | *3.00* | *0.50* | | |
| 7241 | **5.87** | 4.38 | 10.25 | | | | 2.72 | | 2.72 | 0.48 | | 0.85 |
| | *7.70* | *2.30* | *10.00* | *Bn, G, Super* | | | *2.50* | *Bl, Bn, T* | *2.50* | *0.50* | | |
| 7242 | **4.59** | 5.66 | 10.25 | | | | 2.60 | | 2.60 | 0.51 | | 0.82 |
| | *5.70* | *4.30* | *10.00* | *Bn, G, Super* | | | *2.50* | *Bl, Bn, G, T* | *2.50* | *0.50* | | |
| 7109 | | | | | 15.52 | | | | 15.52 | | | |
| 7182 | | | | | 15.32 | | | | 15.32 | | | |
| 7235 | | | | | 15.36 | | | | 15.36 | | | |
| | | | | | *15.00* | | | | *15.00* | | | |
| 7164 | 6.81 | 5.44 | 12.25 | | | | 2.30 | | 2.30 | 5.92 | | 0.75 |
| | | | *11.00* | *Bn, G, Super* | | | *2.00* | *Bl, Bn, G, T, Fs* | *2.00* | *5.00* | | |
| 7165 | 7.51 | 1.44 | 8.95 | | 2.04 | | 2.21 | | 4.25 | 5.63 | | 0.55 |
| | | | *8.00* | *Bn, Super* | *2.00* | | *2.00* | *Bl, Bn* | *4.00* | *5.00* | | |
| 7112 | 9.07 | 3.38 | 12.45 | | 1.84 | | 2.73 | | 4.57 | 0.77 | | 0.57 |
| | | | *10.50* | *Bn, Super* | *1.50* | | *3.00* | *Bn, T* | *4.50* | *0.50* | | |
| 7183 | 8.34 | 3.26 | 11.60 | | 1.18 | 1.04 | 2.63 | | 4.85 | | | |
| 7201 | 6.50 | 4.00 | 10.50 | | 0.15 | 1.50 | 3.71 | | 5.36 | | | |
| | | | *10.00* | *Bn, G, Super* | *1.00* | *1.00* | *3.00* | *Bl, Bn, G, T, Fs* | *5.00* | | | |
| 7184 | 7.69 | 3.66 | 11.35 | | 2.06 | | 2.95 | | 5.01 | 1.04 | | 1.00 |
| | | | *10.50* | *Bn, Super* | *1.50* | | *3.00* | *Bn, T* | *4.50* | *0.50* | | |
| 7243 | 4.80 | 5.00 | 9.80 | | | | 2.59 | | 2.59 | 0.49 | | 0.87 |
| | *5.70* | *4.30* | *10.00* | *Bn, G, Super* | | | *2.50* | *Bl, Bn, G, T* | *2.50* | *0.50* | | |
| 7158 | 5.01 | 5.84 | 10.85 | | 1.39 | 1.56 | 1.08 | | 4.03 | 1.05 | | |
| 7167 | 4.42 | 5.48 | 10.90 | | 1.28 | 1.48 | 1.22 | | 3.98 | 0.99 | | |
| 7233 | **5.48** | 5.92 | 11.40 | | 1.55 | 1.44 | 1.18 | | 4.17 | 1.02 | | |
| | *7.50* | *2.50* | *10.00* | *Bn, G, Super* | *1.50* | *1.50* | *1.00* | *Bl, Bn, G, T* | *4.00* | *1.00* | | |
| 7232 | **6.67** | 5.78 | 12.45 | | 1.52 | | 2.30 | | 3.82 | 1.10 | | 0.67 |
| | *8.00* | *2.00* | *10.00* | *Bn, G, Super* | *1.50* | | *2.50* | *Bl, Bn, G, T* | *4.00* | *1.00* | | |
| 7239 | **5.00** | 6.00 | 11.00 | | 1.54 | | 2.44 | | 3.98 | 0.91 | | 0.62 |
| | *7.50* | *2.50* | *10.00* | *Bn, G, Super* | *1.50* | | *2.50* | *Bl, Bn, G, T* | *4.00* | *1.00* | | |
| 7205 | 18.10 | 0.70 | 18.80 | | | | | | | | | |
| | *17.00* | *1.00* | *18.00* | | | | | | | | | |

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Pacific Guano & Fertilizer Co. San Francisco Cal.** (Continued). | | |
| 7111* | Tankage | A. G. Johnson, Redlands | 49.75 |
| | *Guaranteed* | | *49.83* |
| 7163* | Tankage | A. M. Seeley, Covina | 46.68 |
| | *Guaranteed* | | *44.16* |
| 7170* | Tankage (Armour's) | A. M. Seeley, Covina | **51.53** |
| | *Guaranteed* | | *54.02* |
| 7171* | Tankage (Armour's) | A. M. Seeley, Covina | 49.88 |
| | *Guaranteed* | | *50.82* |
| 7221* | Tankage | Wilson & Hickox, Upland | 45.04 |
| | *Guaranteed* | | *45.86* |
| 7267* | Tankage (Armour's) | W. F. Scott, Villa Park | 46.45 |
| | *Guaranteed* | | *47.45* |
| 7268* | Tankage | W. F. Scott, Villa Park | 52.01 |
| | *Guaranteed* | | *52.80* |
| 7341* | Tankage | A. C. Barnes, Riverside | 51.08 |
| | *Guaranteed* | | *50.40* |
| 7236* | Tankage (Fish Meal) | E. M. Hudson, Los Angeles | 39.66 |
| | *Guaranteed* | | *39.58* |
| 7340 | Sulfate of Ammonia and Tankage | I. W. Haskill, Azusa | 56.03 |
| | *Guaranteed* | | *55.20* |
| 7188 | T. R. K. | Wilson & Hickox, Upland | 40.86 |
| | *Guaranteed* | | *38.80* |
| | **Southern California Fertilizer Co., Los Angeles, Cal.** | | |
| 7096* | Garbage Tankage | J. F. Jackson, Riverside | |
| 7260* | Garbage Tankage | Sierra Madre Lamanda Citrus Assn., Lamanda Park | |
| 7261* | Garbage Tankage | Sierra Madre Lamanda Citrus Assn., Lamanda Park | |
| 7281* | Garbage Tankage | T. W. Frye, Highland | |
| 7301* | Garbage Tankage | J. D. Boley & A. B. Carris, Highland | |
| 7325* | Garbage Tankage | M. T. Durrell, Azusa | |
| 7333* | Garbage Tankage | Mrs. A. R. Pettijohn, Colton | |
| | *Guaranteed* | | |
| 7094* | Fish Scrap | J. F. Jackson, Riverside | 45.14 |
| | *Guaranteed* | | *39.60* |
| 7095 | Fruiting | J. F. Jackson, Riverside | 34.74 |
| | *Guaranteed* | | *30.00* |
| | **W. M. Warren Fertilizer Co., Covina, Cal.** | | |
| 7345 | Mixture | B. L. King, Covina | 56.09 |
| | *Guaranteed* | | *52.80* |
| | **Western Meat Company, San Francisco, Cal.** | | |
| 7098 | Blood | B. L. Byer, Upland | 72.96 |
| 7140 | Blood | F. Manning, Glendora | 71.60 |
| | *Guaranteed* | | *70.20* |
| 7218 | Blood | Wilson & Hickox, Upland | 72.28 |
| | *Guaranteed* | | *71.24* |
| 7262* | Bone Meal, Diamond G | Johnston & Son, Lamanda Park | 44.59 |
| 7139* | Bone Meal, Diamond G | F. Manning, Glendora | 45.36 |
| | *Guaranteed* | | *42.00* |

*7111—80% fine.
*7163—81% fine.
*7170—73% fine.
*7171—79% fine.
*7221—80% fine.
*7267—68% fine.
*7268—80% fine.
*7341—77% fine.
*7236—80% fine.
*7262—81% fine.
*7139—72% fine.

*7096—46% fine.
*7260—43% fine.
*7261—46% fine.
*7281—47% fine.
} In absence of market quotations no prices are given on Garbage Tankage.

*7301—48% fine.
*7325—48% fine.
*7333—38% fine.
*7094—58% fine.
} In absence of market quotations no prices are given on Garbage Tankage.

| | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab. No. | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen Guaranteed as derived from | Total | From Sulfate | Total | Chlorin |
| 7111 | ..... | ..... | 10.55 | ..... | ..... | ..... | 7.73 | ..... | 7.73 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.45* | ..... | ..... | ..... | *7.77* | ..... | *7.77* | ..... | ..... | ..... |
| 7163 | ..... | ..... | 16.50 | ..... | ..... | ..... | 5.60 | ..... | 5.60 | ..... | ..... | ..... |
| ..... | ..... | ..... | *15.75* | ..... | ..... | ..... | *5.25* | ..... | *5.25* | ..... | ..... | ..... |
| 7170 | ..... | ..... | 7.30 | ..... | ..... | ..... | 8.91 | ..... | **8.91** | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.50* | ..... | ..... | ..... | *9.88* | ..... | *9.88* | ..... | ..... | ..... |
| 7171 | ..... | ..... | 12.45 | ..... | ..... | ..... | 7.28 | ..... | 7.28 | ..... | ..... | ..... |
| ..... | ..... | ..... | *12.35* | ..... | ..... | ..... | *7.50* | ..... | *7.50* | ..... | ..... | ..... |
| 7221 | ..... | ..... | 13.25 | ..... | ..... | ..... | 6.07 | ..... | 6.07 | ..... | ..... | ..... |
| ..... | ..... | ..... | *13.18* | ..... | ..... | ..... | *6.26* | ..... | *6.26* | ..... | ..... | ..... |
| 7267 | ..... | ..... | 13.95 | ..... | ..... | ..... | 6.19 | ..... | 6.19 | ..... | ..... | ..... |
| ..... | ..... | ..... | *14.58* | ..... | ..... | ..... | *6.24* | ..... | *6.24* | ..... | ..... | ..... |
| 7268 | ..... | ..... | 11.30 | ..... | ..... | ..... | 8.01 | ..... | 8.01 | ..... | ..... | ..... |
| ..... | ..... | ..... | *12.03* | ..... | ..... | ..... | *7.95* | ..... | *7.95* | ..... | ..... | ..... |
| 7341 | ..... | ..... | 11.25 | ..... | ..... | ..... | 7.83 | ..... | 7.83 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | ..... | ..... | ..... | *8.00* | ..... | *8.00* | ..... | ..... | ..... |
| 7236 | ..... | ..... | 8.65 | ..... | ..... | ..... | 6.10 | ..... | 6.10 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.50* | ..... | ..... | ..... | *6.12* | ..... | *6.12* | ..... | ..... | ..... |
| 7340 | ..... | ..... | 9.65 | ..... | ..... | 8.94 | 0.32 | ..... | 9.26 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | ..... | ..... | ..... | ..... | ..... | *9.00* | ..... | ..... | ..... |
| 7188 | 8.32 | 1.28 | 9.60 | ..... | 2.17 | ..... | 1.73 | ..... | 3.90 | 5.31 | ..... | ..... |
| ..... | ..... | ..... | *8.00* | *Bn, G, Super* | *2.00* | ..... | *2.00* | *Bl, Bn, G, T, Fs* | *4.00* | *5.00* | ..... | ..... |
| 7096 | ..... | ..... | 2.80 | ..... | ..... | ..... | 2.98 | ..... | 2.98 | ..... | 1.24 | 1.22 |
| 7260 | ..... | ..... | 2.70 | ..... | ..... | ..... | 2.83 | ..... | 2.83 | ..... | 1.52 | 1.25 |
| 7261 | ..... | ..... | 2.30 | ..... | ..... | ..... | 2.86 | ..... | 2.86 | ..... | 1.15 | 1.17 |
| 7281 | ..... | ..... | 2.65 | ..... | ..... | ..... | 3.02 | ..... | 3.02 | ..... | 1.30 | 1.35 |
| 7301 | ..... | ..... | 2.45 | ..... | ..... | ..... | 2.93 | ..... | 2.93 | ..... | 1.43 | 0.95 |
| 7325 | ..... | ..... | 2.75 | ..... | ..... | ..... | 3.17 | ..... | 3.17 | ..... | 1.44 | 1.37 |
| 7333 | ..... | ..... | 2.60 | ..... | ..... | ..... | 2.90 | ..... | 2.90 | ..... | 1.34 | 1.32 |
| ..... | ..... | ..... | *2.25* | ..... | ..... | ..... | *2.75* | ..... | *2.75* | ..... | *1.25* | ..... |
| 7094 | ..... | ..... | 7.90 | ..... | ..... | ..... | 7.43 | ..... | 7.43 | ..... | ..... | ..... |
| ..... | ..... | ..... | *5.00* | ..... | ..... | ..... | *7.00* | ..... | *7.00* | ..... | ..... | ..... |
| 7095 | 7.73 | 1.42 | 9.15 | ..... | 0.78 | 1.30 | 1.60 | ..... | 3.68 | 3.05 | ..... | ..... |
| ..... | *7.00* | *1.00* | *8.00* | *Bn, Super, T* | *1.00* | *0.80* | *1.20* | *Bl, Bn, G, T* | *3.00* | *3.00* | ..... | ..... |
| 7345 | ..... | ..... | 5.10 | ..... | ..... | 3.09 | 7.32 | ..... | 10.41 | ..... | ..... | ..... |
| ..... | ..... | ..... | *4.00* | *Bat G, Bn, T* | ..... | *2.00* | *8.00* | *Bat G, Bl, Bn, T* | *10.00* | ..... | ..... | ..... |
| 7098 | ..... | ..... | ..... | ..... | ..... | ..... | 14.03 | ..... | 14.03 | ..... | ..... | ..... |
| 7140 | ..... | ..... | ..... | ..... | ..... | ..... | 13.77 | ..... | 13.77 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.50* | ..... | *13.50* | ..... | ..... | ..... |
| 7218 | ..... | ..... | ..... | ..... | ..... | ..... | 13.90 | ..... | 13.90 | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... | ..... | ..... | ..... | *13.70* | ..... | *13.70* | ..... | ..... | ..... |
| 7262 | ..... | ..... | 30.00 | ..... | ..... | ..... | 1.79 | ..... | 1.79 | ..... | ..... | ..... |
| 7139 | ..... | ..... | 31.00 | ..... | ..... | ..... | 1.70 | ..... | 1.70 | ..... | ..... | ..... |
| ..... | ..... | ..... | *27.00* | ..... | ..... | ..... | *2.00* | ..... | *2.00* | ..... | ..... | ..... |

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Western Meat Company** (Continued.) **San Francisco, Cal.** | | |
| 7079 | Diamond D | J. Henry Reynolds, Redlands | 37.18 |
| 7128 | Diamond D | B. L. Byer, Upland | 40.33 |
| 7141 | Diamond D | F. Manning, Glendora | 37.67 |
| | *Guaranteed* | | *35.20* |
| 7124 | Diamond M | B. L. Byer, Upland | 35.51 |
| 7264 | Diamond M | Johnston & Son, Lamanda Park | 35.68 |
| 7287 | Diamond M | Earl M. Harvey, Nuevo | 33.43 |
| 7289 | Diamond M | B. J. Mather, Nuevo | 32.87 |
| | *Guaranteed* | | *32.80* |
| 7060 | Special | El Dorado Potato Growers Assn., Placerville | 40.04 |
| | *Guaranteed* | | *38.80* |
| 7075 | Special | J. Henry Reynolds, Redlands | 34.87 |
| | *Guaranteed* | | *28.40* |
| 7076* | Special | J. Henry Reynolds, Redlands | 31.98 |
| | *Guaranteed* | | *31.20* |
| 7078* | Special | J. Henry Reynolds, Redlands | 35.96 |
| | *Guaranteed* | | *36.00* |
| 7104 | Special | B. L. Byer, Upland | 46.49 |
| | *Guaranteed* | | *48.00* |
| 7077* | Special | J. Henry Reynolds, Redlands | 42.72 |
| 7101* | Special | B. L. Byer, Upland | 44.21 |
| 7127* | Special | B. L. Byer, Upland | 44.18 |
| | *Guaranteed* | | *42.24* |
| 7102 | Special | B. L. Byer, Upland | 40.38 |
| | *Guaranteed* | | *35.20* |
| 7152 | Special | B. L. Byer, Upland | 38.77 |
| 7207 | Special | B. L. Byer, Upland | 41.42 |
| | *Guaranteed* | | *35.20* |
| 7263 | Special | Johnston & Son, Lamanda Park | 37.64 |
| | *Guaranteed* | | *35.20* |
| 7103 | Special | B. L. Byer, Upland | 46.06 |
| 7133 | Special | B. L. Byer, Upland | 45.24 |
| 7154 | Special | B. L. Byer, Upland | 46.78 |
| 7172 | Special | B. L. Byer, Upland | 46.04 |
| | *Guaranteed* | | *42.40* |
| 7137 | Special | F. Manning, Glendora | 44.82 |
| | *Guaranteed* | | *42.40* |
| 7153 | Special | B. L. Byer, Upland | 47.23 |
| 7173 | Special | B. L. Byer, Upland | 45.41 |
| | *Guaranteed* | | *42.40* |
| 7129 | Special | B. L. Byer, Upland | 35.68 |
| | *Guaranteed* | | *34.68* |
| 7132 | Special | B. L. Byer, Upland | 50.30 |
| | *Guaranteed* | | *48.80* |
| 7135 | Special | B. L. Byer, Upland | 40.95 |
| | *Guaranteed* | | *37.28* |
| 7138 | Special | F. Manning, Glendora | 54.59 |
| | *Guaranteed* | | *52.40* |
| 7130 | Special | B. L. Byer, Upland | 39.60 |
| | *Guaranteed* | | *37.28* |

*7076—78% fine as tankage.
*7078—74% fine as tankage.
*7077—58% fine as bone.
*7101—58% fine as bone.
*7127—59% fine as bone.

| | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab. No. | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen Guaranteed as derived from | Total | From Sulfate | Total | Chlorin |
| 7079 | 7.22 | 3.28 | 10.50 | ..... | 0.70 | ..... | 3.50 | ..... | 4.20 | ..... | 2.21 | 1.05 |
| 7128 | **4.45** | 6.90 | 11.35 | ..... | 0.69 | ..... | 3.65 | ..... | 4.34 | 2.94 | ..... | ..... |
| 7141 | **4.16** | 6.84 | 11.00 | ..... | 0.71 | ..... | 3.48 | ..... | 4.19 | ..... | 2.18 | 1.07 |
| ..... | *8.00* | *2.00* | *10.00* | *Bn, Super* | *1.00* | ..... | *3.00* | *Animal Matter* | *4.00* | *2.00* | ..... | ..... |
| 7124 | **6.27** | 4.68 | 10.95 | ..... | 0.91 | ..... | 2.23 | ..... | 3.14 | 3.65 | ..... | 1.00 |
| 7264 | **5.08** | 4.92 | 10.00 | ..... | 0.93 | ..... | 2.44 | ..... | 3.37 | 3.75 | ..... | 0.60 |
| 7287 | **4.34** | 5.76 | 10.10 | ..... | 0.63 | ..... | 2.23 | ..... | 2.86 | ..... | 3.79 | 1.07 |
| 7289 | **6.44** | 2.76 | 9.20 | ..... | 0.90 | ..... | 1.99 | ..... | 2.89 | ..... | 3.98 | 1.10 |
| ..... | *8.00* | *1.50* | *9.50* | *Bn, Super* | *1.00* | ..... | *2.00* | *Animal Matter* | *3.00* | *3.50* | ..... | ..... |
| 7060 | 6.58 | 2.32 | 8.90 | ..... | 0.78 | ..... | 2.94 | ..... | **3.72** | ..... | 5.75 | 1.80 |
| ..... | ..... | ..... | *8.00* | *Bn, Super* | *2.00* | ..... | *2.00* | *Animal Matter* | *4.00* | *5.00* | ..... | ..... |
| 7075 | ..... | ..... | 10.45 | ..... | ..... | ..... | 4.16 | ..... | 4.16 | ..... | 1.18 | 1.45 |
| ..... | ..... | ..... | *10.00* | *Bn, Super* | ..... | ..... | *3.00* | *Animal Matter* | *3.00* | *1.00* | ..... | ..... |
| 7076 | ..... | ..... | 10.45 | ..... | ..... | ..... | 4.05 | ..... | 4.05 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | *Bn* | ..... | ..... | *4.00* | *Animal Matter* | *4.00* | ..... | ..... | ..... |
| 7078 | ..... | ..... | 10.05 | ..... | ..... | ..... | 4.98 | ..... | 4.98 | ..... | ..... | ..... |
| ..... | ..... | ..... | *10.00* | *Bn, Super* | ..... | ..... | *5.00* | *Animal Matter* | *5.00* | ..... | ..... | ..... |
| 7104 | 4.66 | 3.64 | 8.30 | ..... | 3.04 | ..... | 4.57 | ..... | 7.61 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | *Bn, Super* | *3.00* | ..... | *5.00* | *Animal Matter* | *8.00* | ..... | ..... | ..... |
| 7077 | ..... | ..... | 20.00 | ..... | ..... | ..... | 3.90 | ..... | 3.90 | ..... | ..... | ..... |
| 7101 | ..... | ..... | 21.60 | ..... | ..... | ..... | 3.81 | ..... | 3.81 | ..... | ..... | ..... |
| 7127 | ..... | ..... | 20.50 | ..... | ..... | ..... | 4.08 | ..... | 4.08 | ..... | ..... | ..... |
| ..... | ..... | ..... | *20.00* | *Bn* | ..... | ..... | *3.80* | *Animal Matter* | *3.80* | ..... | ..... | ..... |
| 7102 | ..... | ..... | 10.90 | ..... | ..... | 1.08 | 3.45 | ..... | 4.53 | 2.78 | ..... | 0.95 |
| ..... | ..... | ..... | *10.00* | *Bn, Super* | ..... | *1.00* | *3.00* | *Animal Matter* | *4.00* | *2.00* | ..... | ..... |
| 7152 | 3.95 | 6.00 | 9.95 | ..... | 0.63 | ..... | 4.08 | ..... | 4.71 | 2.11 | ..... | ..... |
| 7207 | ..... | ..... | 12.00 | ..... | 0.76 | ..... | 3.74 | ..... | 4.50 | ..... | 2.71 | 1.22 |
| ..... | ..... | ..... | *10.00* | *Bn, Super* | *1.00* | ..... | *3.00* | *Animal Matter* | *4.00* | *2.00* | ..... | ..... |
| 7263 | ..... | ..... | 11.25 | ..... | ..... | ..... | 4.10 | ..... | 4.10 | ..... | 2.23 | 1.32 |
| ..... | ..... | ..... | *10.00* | *Bn* | ..... | ..... | *4.00* | *Animal Matter* | *4.00* | *2.00* | ..... | ..... |
| 7103 | ..... | ..... | 9.85 | ..... | ..... | 1.98 | 4.10 | ..... | 6.08 | ..... | 2.53 | 1.20 |
| 7133 | ..... | ..... | 9.00 | ..... | ..... | 2.33 | 3.78 | ..... | 6.11 | ..... | 2.56 | 1.40 |
| 7154 | ..... | ..... | 9.40 | ..... | ..... | 2.23 | 4.22 | ..... | 6.45 | 2.27 | ..... | 0.62 |
| 7172 | 4.14 | 4.86 | 9.00 | ..... | ..... | 2.14 | 4.21 | ..... | 6.35 | 2.38 | ..... | 0.90 |
| ..... | ..... | ..... | *8.00* | *Bn, Super* | ..... | *2.00* | *4.00* | *Animal Matter* | *6.00* | *2.00* | ..... | ..... |
| 7137 | ..... | ..... | 8.10 | ..... | ..... | ..... | 6.58 | ..... | 6.58 | ..... | 1.76 | 1.57 |
| ..... | ..... | ..... | *8.00* | *Bn, Super* | ..... | ..... | *6.00* | *Animal Matter* | *6.00* | *2.00* | ..... | ..... |
| 7153 | 4.32 | 4.98 | 9.30 | ..... | 1.56 | ..... | 4.70 | ..... | 6.26 | 3.01 | ..... | 0.62 |
| 7173 | 4.01 | 3.94 | 7.95 | ..... | 2.46 | ..... | 3.75 | ..... | 6.21 | 3.03 | ..... | 1.00 |
| ..... | ..... | ..... | *8.00* | *Bn, Super* | *2.00* | ..... | *4.00* | *Animal Matter* | *6.00* | *2.00* | ..... | ..... |
| 7129 | ..... | ..... | 10.65 | ..... | 1.51 | 0.74 | 1.43 | ..... | **3.68** | ..... | 2.62 | 1.02 |
| ..... | ..... | ..... | *10.00* | *Bn, Super* | *2.35* | *0.75* | *1.00* | *Animal Matter* | *4.10* | *1.50* | ..... | ..... |
| 7132 | ..... | ..... | 10.80 | ..... | ..... | ..... | 6.18 | ..... | 6.18 | ..... | 3.84 | 2.00 |
| ..... | ..... | ..... | *10.00* | *Bn, Super* | ..... | ..... | *6.00* | *Animal Matter* | *6.00* | *4.00* | ..... | ..... |
| 7135 | ..... | ..... | 20.60 | ..... | ..... | ..... | 1.26 | ..... | 1.26 | ..... | 5.09 | 1.02 |
| | ..... | ..... | *19.60* | *Bn* | ..... | ..... | *1.20* | *Animal Matter* | *1.20* | *4.00* | ..... | ..... |
| 7138 | ..... | ..... | 15.65 | ..... | ..... | 4.65 | 2.81 | ..... | **7.46** | ..... | ..... | ..... |
| | ..... | ..... | *15.00* | *Bn* | ..... | *5.00* | *3.00* | *Animal Matter* | *8.00* | ..... | ..... | ..... |
| 7130 | ..... | ..... | 8.60 | ..... | ..... | 2.17 | 3.01 | ..... | 5.18 | 2.21 | ..... | 0.87 |
| | ..... | ..... | *8.00* | *Bn, Super* | ..... | *1.50* | *3.50* | *Animal Matter* | *5.00* | *2.00* | ..... | ..... |

| Lab. No. | Name and Address of Manufacturer or Dealer, and Name of Brand | From Whom Obtained | Value per ton |
|---|---|---|---|
| | **Western Meat Company,** (Continued) **San Francisco, Cal.** | | |
| 7134 | Special | B. L. Byer, Upland | 39.04 |
| 7151 | Special | B. L. Byer, Upland | 45.04 |
| | *Guaranteed* | | *57.60* |
| 7288 | Special | B. J. Mather, Nuevo | 34.54 |
| | *Guaranteed* | | *32.00* |
| 7328 | Special | W. M. Baird, Duarte | 56.93 |
| 7330 | Special | W. M. Baird, Duarte | 57.34 |
| 7334 | Special | W. M. Baird, Duarte | 56.74 |
| | *Guaranteed* | | *57.60* |
| 7126 | Superphosphate | B. L. Byer, Upland | 23.37 |
| | *Guaranteed* | | *21.60* |
| 7155* | Tankage Diamond E | B. L. Byer, Upland | 45.91 |
| | *Guaranteed* | | *45.60* |
| 7074* | Tankage | J. Henry Reynolds, Redlands | 40.20 |
| | *Guaranteed* | | *38.40* |
| 7069* | Tankage | E. L. Koethen, Riverside | 43.06 |
| 7099* | Tankage | B. L. Byer, Upland | 48.19 |
| 7100* | Tankage | B. L. Byer, Upland | 41.86 |
| 7125* | Tankage | B. L. Byer, Upland | 45.99 |
| 7156* | Tankage | B. L. Byer, Upland | 44.81 |
| | *Guaranteed* | | *42.18* |
| 7143* | Tankage | F. Manning, Glendora | 49.34 |
| | *Guaranteed* | | *48.73* |
| 7070* | Tankage | E. L. Koethen, Riverside | 48.94 |
| 7131* | Tankage | B. L. Byer, Upland | 50.36 |
| 7142* | Tankage | F. Manning, Glendora | 49.08 |
| 7304* | Tankage | William Gosan, Upland | 46.73 |
| 7342* | Tankage | F. A. Briggs, Riverside | 47.39 |
| | *Guaranteed* | | *48.00* |

*7155—81% fine.
*7074—69% fine.
*7069—76% fine.
*7099—76% fine.
*7100—88% fine.
*7125—81% fine.
*7156—67% fine.
*7143—68% fine.
*7070—71% fine.
*7131—76% fine.
*7142—62% fine.
*7304—70% fine.
*7342—73% fine.

| | Phosphoric Acid | | | | Nitrogen | | | | | Potash | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab. No. | Available | Insoluble | Total | Guaranteed as derived from | In Nitrates | In Ammonia Salts | Organic | Organic Nitrogen Guaranteed as derived from | Total | From Sulfate | Total | Chlorin |
| 7134 | 4.16 | 4.24 | 8.40 | ..... | 1.72 | ..... | 3.13 | ..... | 4.85 | ..... | 2.84 | 1.67 |
| 7151 | 4.03 | 6.12 | 10.15 | ..... | 0.58 | ..... | 5.47 | ..... | 6.05 | 1.91 | ..... | 0.65 |
| ..... | ..... | ..... | *8.00* | *Bn, Super* | *1.50* | ..... | *3.50* | *Animal Matter* | *5.00* | *2.00* | ..... | ..... |
| 7288 | ..... | ..... | 9.25 | ..... | 0.75 | 1.04 | 1.31 | ..... | 3.10 | ..... | 4.28 | 1.17 |
| ..... | ..... | ..... | *8.00* | *Bn, Super* | *1.00* | *1.00* | *1.00* | *Animal Matter* | *3.00* | *4.00* | ..... | ..... |
| 7328 | ..... | ..... | 8.00 | ..... | ..... | 7.20 | 2.66 | ..... | 9.86 | ..... | ..... | ..... |
| 7330 | ..... | ..... | 8.10 | ..... | ..... | 6.95 | 2.97 | ..... | 9.92 | ..... | ..... | ..... |
| 7334 | ..... | ..... | 8.20 | ..... | ..... | 6.59 | 3.18 | ..... | 9.77 | ..... | ..... | ..... |
| ..... | ..... | ..... | *8.00* | *T* | *8.00* | *2.00* | ..... | *T* | *10.00* | ..... | ..... | ..... |
| 7126 | 19.48 | 0.32 | 19.80 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| ..... | ..... | ..... | *18.00* | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 7155 | ..... | ..... | 17.70 | ..... | ..... | ..... | 5.14 | ..... | 5.14 | ..... | ..... | ..... |
| ..... | ..... | ..... | *18.00* | ..... | ..... | ..... | *5.00* | ..... | *5.00* | ..... | ..... | ..... |
| 7074 | ..... | ..... | 4.70 | ..... | ..... | ..... | 7.20 | ..... | 7.20 | ..... | ..... | ..... |
| ..... | ..... | ..... | *4.00* | ..... | ..... | ..... | *7.00* | ..... | *7.00* | ..... | ..... | ..... |
| 7069 | ..... | ..... | 14.80 | ..... | ..... | ..... | 5.27 | ..... | 5.27 | ..... | ..... | ..... |
| 7099 | ..... | ..... | **12.60** | ..... | ..... | ..... | 6.89 | ..... | 6.89 | ..... | ..... | ..... |
| 7100 | ..... | ..... | 14.20 | ..... | ..... | ..... | 5.17 | ..... | 5.17 | ..... | ..... | ..... |
| 7125 | ..... | ..... | 16.25 | ..... | ..... | ..... | 5.52 | ..... | 5.52 | ..... | ..... | ..... |
| 7156 | ..... | ..... | 15.90 | ..... | ..... | ..... | 5.36 | ..... | 5.36 | ..... | ..... | ..... |
| ..... | ..... | ..... | *13.75* | ..... | ..... | ..... | *5.35* | ..... | *5.35* | ..... | ..... | ..... |
| 7143 | ..... | ..... | 16.20 | ..... | ..... | ..... | 6.23 | ..... | 6.23 | ..... | ..... | ..... |
| ..... | ..... | ..... | *16.13* | ..... | ..... | ..... | *6.12* | ..... | *6.12* | ..... | ..... | ..... |
| 7070 | ..... | ..... | 8.10 | ..... | ..... | ..... | 8.17 | ..... | 8.17 | ..... | ..... | ..... |
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| ..... | ..... | ..... | *8.00* | ..... | ..... | ..... | *8.00* | ..... | *8.00* | ..... | ..... | ..... |

## REPORT OF ANALYSIS

Available phosphoric acid is not determined in bone, meal, tankage, and Thomas phosphate powder, unless requested. The fineness of these materials is determined, fine and medium bone being separated by a sieve of 50 meshes to the inch; tankage by a 25-mesh sieve; and Thomas phosphate powder by a 100-mesh sieve.

Nitrogen in ammonium salts, will, in some cases, be found reported when nitrogen in this form is not guaranteed. In some of such cases this form of nitrogen is produced by conversion of organic nitrogen during process of manufacture, and is not to be considered a deviation from guaranty of materials used. Guanos carry more or less nitrogen in nitrates and ammonium salts, and when any appreciable quantity of guano is used the manufacturer should take into account the fact that some nitrogen will show as nitrates and ammonium salts. The failure to take this into consideration may account for the appearance of these forms of nitrogen in some samples in which only organic nitrogen was guaranteed.

The perçentage of chlorin is given when it exceeds 0.50 per cent. It is a matter of only technical interest whether chlorin present is from muriate of potash, kainit, or from common salt that may be in some of the materials used. If a manufacturer uses sulfate of potash and a tankage with it containing a large amount of chlorin, from a practical standpoint he has changed the quality of his fertilizer just as much as if he had used muriate of potash instead of sulfate of potash. Chlorin from all other sources has the same effect as if from muriate of potash. However, if muriate of potash is found when sulfate is guaranteed, the fact will be published.

The following abbreviations are used in the tables: Bat G, = bat guano, Bl = blood, Bn = bone, Fs = fish, G = guano, H = hoof, Min. Phos = mineral phosphate, Super = superphosphates, T = tankage. CSM = cotton seed meal.

Guarantees are entered in italics. Deficiencies greater than those allowed by law are entered in bold faced type.

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# CONTROL OF GROUND SQUIRRELS BY THE FUMIGATION METHOD

BY
G. R. STEWART AND JOHN S. BURD

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# CONTROL OF GROUND SQUIRRELS BY THE FUMIGATION METHOD

By G. R. STEWART and JOHN S. BURD

In the present war emergency the stimulation of food production has become the active aim of everyone connected with agriculture. It is evident that anything which prevents loss of food after it is raised is just as important as an increase in the annual crop. Probably the greatest preventable loss of foodstuffs in the State of California is due to the depredations of the common ground squirrel. This animal is estimated by various authorities[1] to consume from five to twenty million dollars worth of food and forage annually in California. In some of the larger single counties the loss is said to reach five hundred thousand dollars yearly. This explains the present active interest in ground-squirrel control. The present investigation was undertaken to aid this emergency work and to assist in the campaigns carried on by the Horticultural Commissioners and by the Farm Bureaus of the state.

The five most important methods of ground-squirrel control, as pointed out by Dixon in Circular 181 of this station, are: "(1) poisoning with strychnine; (2) fumigation with carbon bisulfide; (3) trapping; (4) shooting; (5) encouragement of the natural enemies of the ground squirrel." The first of these methods, poisoning with strychnine-coated barley, is undoubtedly the most satisfactory and the least expensive to use for a preliminary treatment. The work of the United States Biological Survey, the United States Public Health Service, and of several state experiment stations, has shown that the intelligent distribution of poisoned barley will remove approximately ninety per cent of the squirrel population. Reducing the remaining ten per cent should be the constant aim of effective squirrel control. The females of this small fraction will produce an average of eight young in a litter. If these young are added to the mature survivors there will be at least half as many squirrels to eat the crop as were present before the poisoning started. It can be readily seen that a follow-up treatment is essential after each poisoning campaign. The aim of squirrel extermination should be to remove all possible survivors before the breeding season. One female killed in March may remove as many as nine from the grain fields the next July.

The best method which has so far been devised for removing the remaining squirrels is fumigation with carbon bisulfide. This does not depend on the co-operation of the squirrels as does poisoning. When green food is abundant it has been noticed that many squirrels will not eat the poisoned grain. Others are especially strong and vigorous and so escape the action of the poison. With carbon bisulfide all that is necessary is to bring the squirrel into an atmosphere which contains approximately 2% of the gas and keep it there for at least twenty minutes.

Carbon bisulfide is best used when the ground is moist. The soil does not then absorb the gas in the open pore spaces and the cracks are closed through which it might escape. If carbon bisulfide is used at other seasons of the year either larger quantities must be employed or special apparatus must be used which will pump the gas through the burrow with sufficient speed to send it to the nest chamber before it has a chance to be absorbed by the soil.

## CARBON BISULFIDE AS A FUMIGANT

The first person to use carbon bisulfide as a method of squirrel control was Dr. E. W. Hilgard, for many years director of this station. In 1876[2] he advised its use upon squirrels because he had noted it was successfully used in France to exterminate rats in sewers. Two years later[3] he described his work on the university campus, and the successful manner in which he had removed the greater part of the squirrels from the gardens.

Since that time three general methods of use have been developed. The first is that originally recommended by Dr. Hilgard. One to two ounces of carbon bisulfide are poured on cotton waste and placed deep down in one or two of the most used entrances of each burrow; all holes are closed with clods of earth or sod. These are inspected the following day to observe whether the treatment has been effective. The few which have been opened by the squirrel are re-treated with a slightly larger dose and inspected later. This is commonly termed "waste ball" method of treatment.

Another very effective procedure has been developed by the United States Public Health Service. In it a machine called a "destructor"[4] is employed to drive the carbon bisulfide gas into the further ends of the burrow. The detailed plan of this instrument was reproduced in Circular 181 of this station. Briefly, it consists of a pump of large bore which forces a strong current of air through a chamber in which a measured quantity of carbon bisulfide is vaporized. The outlet hose of the machine is thrust down one of the principal entrances of the

squirrel burrow, the soil is filled in around it and all other entrances are closed. About fifteen double strokes of the pump are sufficient to fill the burrow with a deadly quantity of gas. One or two cheaper machines have been devised, but so far as the writers have been able to learn, neither these nor the "destructor" are at present on the market. This is due partly to the present high cost of the materials employed and partly to a lack of appreciation of the greater efficiency which is achieved by the use of a pump machine.

The other variation in the use of carbon bisulfide consists in exploding the gas in the burrow. Carbon bisulfide is extremely inflammable and very explosive. The common procedure is to place the waste ball saturated with carbon bisulfide in the burrow, close the entrance with a loose clod of earth for two or three minutes to allow the gas to vaporize, then to remove the clod and stepping back and to one side to apply a small lighted torch consisting of a cloth soaked in kerosene wrapped around a thin piece of pipe. The explosion will be extremely vigorous and has the advantage of indicating whether all the entrances of the burrow have been previously closed. This method of operation should never be employed when the grass is at all dry. Many serious fires have been caused in this way during the drier periods of the year.

All three methods of fumigation have had their advocates in the past. There is good evidence from the figures of Surgeon Long[4] that the treatment by machines of the destructor type is the most economical. He found that 200 to 250 holes per gallon could be treated with the destructor, against 50 to 60 holes by the waste ball method.

The question of the relative effectiveness of the exploded as compared to the unexploded gas depends upon two factors, viz., whether the exploded or the unexploded gas is the more poisonous, and the completeness with which either gas is distributed into the more distant parts of the burrow. If the unexploded and exploded gas are equally poisonous the more effective of the two methods is the one which will distribute the gas the more quickly and thoroughly. If the unexploded and exploded gas are not equally poisonous the more poisonous form may be the more effective even if its dissemination is slower. A knowledge of the kinds and amounts of gas resulting from the explosion of carbon bisulfide and a comparative study of their toxicity to squirrels is therefore an important part of the present investigation.

It has been generally assumed that the products of the explosion of carbon bisulfide in an excess of air consist exclusively of carbon dioxide and sulfur dioxide. This assumption is not justified, because the course of the reaction may be modified by several factors. In

the field the conditions which are most likely to affect the explosion and change the products of combusion are, the humidity of the air, the temperature, and the atmospheric pressure. It is also possible that the products formed from gaseous carbon bisulfide will be different from those produced from burning the liquid material.

We have found in laboratory experiments reported elsewhere[5] that where carbon bisulfide is completely vaporized and exploded in the presence of an excess of air, the largest portion of the gas (40% to 60%) went to form carbon dioxide and sulfur dioxide, from 25 to 35% formed carbon monoxide and sulfur dioxide, and 15 to 30% remained unexploded.

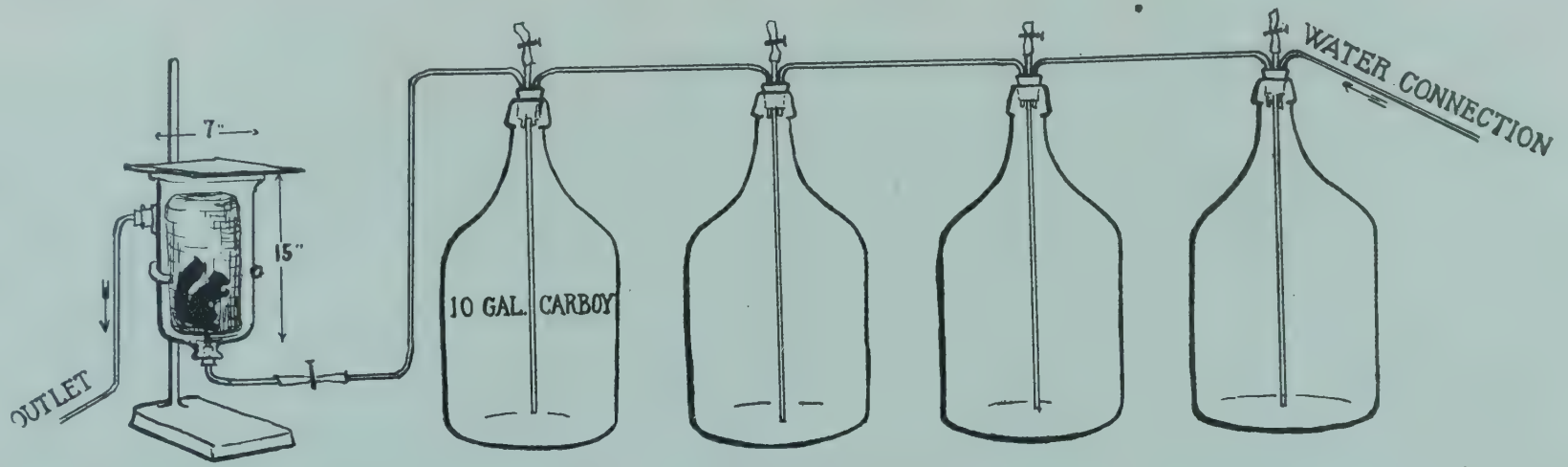
The carbon dioxide formed is well known to be non-poisonous. It is the gas used to carbonate soda water and similar beverages. The only way that it could cause death would be if it were present in such large amount that it excluded the air. The squirrel would then die from suffocation; this would require a vastly greater quantity than is ever present from the explosion in the burrow.

Carbon monoxide, on the contrary, is poisonous to both animals and human beings if as much as one-tenth of one per cent is present in the air. This carbon monoxide is the principal cause of the poisonous effects from illuminating gas in which it may be present in amounts of two to twenty per cent.

The effect of the sulfur dioxide is less well known. The Selby Smelter Commission[6] found five-hundredths of one per cent of sulfur dioxide caused a sense of acute suffocation to human beings, but no exact information has been found as to its effect on squirrels.

## EXPERIMENTS WITH SQUIRRELS

In the earlier of these experiments an exact mixture of carbon bisulfide and air was made up in a series of communicating carboys. The outlet of these carboys was connected with the lower opening of a glass bell jar of sufficient size to contain a wire cage in which the squirrel was placed. A gentle stream of water was then passed into the farthest carboy which caused a steady current of gas to flow through the bell jar. In this manner the squirrel, kept in an atmosphere of constant composition, was at all times under observation. Only a portion of the gas contained in the system was used in any set of experiments. The composition of the part which the squirrel breathed therefore could not be changed by coming in contact with the water. The plan of this apparatus is indicated in Figure 1. In this manner squirrels were treated with air containing 4%, 2%, and 1% carbon bisulfide.




Rig. 1. Fumigration Apparatus.

DESIGN OF ARTIFICIAL BURROW

Fig. 2

The detailed results of the treatments are given in Table I. It was found that 4% gas did not kill the squirrels more quickly than 2%, while 1% was too weak to be fatal within less than an hour and a half. With 2% gas the squirrels partially collapsed in from six to ten minutes and in seventeen to twenty minutes had ceased breathing.

TABLE I.

EXPERIMENTS WITH VARYING CONCENTRATIONS OF CARBON BISULPHIDE

| Percentage of gas | Manner of use | Sex | Weight | Time of Treatment | Result |
|---|---|---|---|---|---|
| 4% | Unexploded, constant current of gas | female | | 22 min. | death |
| 4% | Unexploded, constant current of gas | male | 537 g. | 13 min. | recovered |
| 4% | Unexploded, constant current of gas | male | 575 g. | 14 min. | recovered |
| 2% | Unexploded, constant current of gas | male | 651 g. | 21 min. | death |
| 2% | Unexploded, constant current of gas | male | 633 g. | 17½ min. | death |
| 2% | Unexploded, caged, artificial burrow | female | small | 20 min. | death |
| 2% | Unexploded, caged, artificial burrow | male | large | 20 min. | death |
| 2% | Unexploded, caged, artificial burrow | female | small | 21 min. | death |
| 1% | Unexploded, constant current of gas | male | 537 g. | 1 hr. | recovered |
| 1% | Unexploded, constant current of gas | male | 575 g. | 1½ hrs. | death |
| 4% | Exploded, caged, artificial burrow | female | small | 16 min. | death |
| 2% | Exploded, caged, artificial burrow | female | pregnant | 15 min. | death |
| 2% | Exploded, caged, artificial burrow | male | old, large | 20 min. | death |
| 2% | Exploded, caged, artificial burrow | female | small | 23 min. | death |
| 2% | Exploded, caged, artificial burrow | female | large, strong | 39 min. | death |

An artificial burrow was next constructed from 5-foot lengths of six-inch iron soil pipe. By joining several of these together with wet clay it was possible to modify the length and volume of the burrow and also change its elevation when desired. A length of eleven feet was first employed. The upper end was closed by a tight wooden cover firmly wired on and plastered with clay to prevent escape of gas. In this wooden cover an inch hole was bored and closed with a rubber stopper. Through this hole measured amounts of carbon bisulfide could be added and on vaporizing could readily flow toward the other end of the pipe which was placed a few inches lower. The squirrel was placed in a large glass specimen jar, the upper end of which was covered with wire screen. The mouth of this jar was shoved into the expanded end of the pipe and the space between the neck of the jar and the pipe packed with clay The squirrel remained in plain view from the outside and could not escape into the pipe, but still received gas just as readily as if he had been within the pipe. The form of the artificial burrow is shown in Figure 2.

A number of squirrels were treated with carbon bisulfide in this artificial burrow and succumbed in approximately the same time with both 2% and 4% gas as did those which had been placed in a stream of gas in the glass bell-jar.

A second group of squirrels were now treated in this artificial burrow with 4% and 2% gas which had been exploded. The carbon bisulfide was added through the hole in the cover at the upper end of the burrow and three minutes was allowed to elapse in order to give the liquid time to vaporize. A lighted match was then thrust in the hole and a vigorous explosion followed. The white smoke resulting from the explosion was driven through the pipe and into the glass jar containing the squirrel. It was evident that the explosion had some slight effect in distributing the gas more thoroughly throughout the pipe. None of the squirrels in any of the experiments appeared to be at all harmed by the explosion. They were clearly frightened but did not appear to be injured in any way by the concussion or by the flame which generally ran through the pipe. The squirrels which were treated with the exploded gas showed a little greater variation in the effect which the gas had upon them than had been the case with the unexploded carbon bisulfide. In general, however, they succumbed in practically the same time from the effects of both the exploded and unexploded gas.

Autopsies were performed by Dr. G. H. Hart on a number of the squirrels which had succumbed to the exploded gas and on others killed by the unexploded mixture. The animals killed by the unexploded gas did not show any characteristic lesions. Their appearance was in all ways similar to that of an animal which had been killed by any anaesthetic such as ether or chloroform. The squirrels killed by the exploded gas exhibited the pink coloration of the lungs which brightens on exposure to the air and which is commonly caused by sulfur dioxide reacting with the coloring matter of the blood. There was no definite general bright coloration of the body cavity characteristic of carbon-monoxide poisoning, but samples of the blood examined by the delicate spectroscope test clearly showed the presence of carbon monoxide, indicating that this gas had contributed to the death of the squirrels.

In order to determine what portion of the effect of the exploded gas was due to the sulfur dioxide, two squirrels were treated with a constant current of this gas in the glass bell-jar previously described. The first squirrel was kept in ¼% sulfur dioxide gas which is five times as strong as the Selby Smelter Commission has found unsupportable by human beings. At the close of an hour the squirrel was

entirely unharmed and did not appear greatly inconvenienced at any time. A second animal was then placed in 2% sulfur dioxide and after thirty-seven minutes exposure succumbed. It was not overcome by the gas at an early stage of the treatment, as is the case with carbon bisulfide, either exploded or unexploded. In fact, it was able to move about till just before its death and had it been removed earlier would probably have recovered. Sulfur dioxide is apparently about half as deadly as carbon bisulfide of the same concentration, but twice as much sulfur dioxide is formed by the explosion. Considering the sulfur dioxide alone we might expect that the exploded and unexploded gases would be equally poisonous, but if sulfur dioxide were the only poisonous substance present the squirrel would be overcome very slowly. Since the squirrel is overcome and collapses in practically the same time with the exploded mixture, we infer that the small amount of carbon monoxide formed contributes materially to the effects causing the death of the animals. The only point which was noticed that indicated that the exploded gas might be any more effective than the unexploded, was the action upon fleas. The fleas found upon the squirrels killed in the exploded carbon bisulfide were all dead, while those on the squirrels killed in the unexploded gas revived soon after they were brought into the open air.

## FLOW OF GAS UPHILL

The next point studied with the artificial burrow was the rate of flow of gas around corners and up-hill. This is a matter of great importance in the efficiency of practical operations in the field. It is generally difficult to say which direction a burrow takes underground. It will therefore be impossible to tell whether the carbon bisulfide, applied with a waste ball, is placed at the highest point of a burrow or whether the farther runways rise to a higher elevation. If the gas cannot rise over elevations of one to two feet it is extremely doubtful whether the fumigation will be effective.

The soil pipe was now extended to four lengths and two right angle bends placed in it. The bottle with the squirrel was inserted in the upper end of the pipe and the carbon bisulfide added through the opening in the lower end. The difference in elevation was slightly over eighteen inches and the distance between the two ends was twenty-two and a half feet.

The first squirrel was fumigated with 2% carbon bisulfide. Approximately thirty minutes elapsed before the squirrel appeared to detect any odor of the gas and a treatment of twenty minutes more was entirely without effect, the squirrel being apparently uninjured.

A second squirrel was treated with 2% carbon bisulfide and the gas exploded. The explosion was not vigorous, because the heavy vapor had not spread sufficiently far up the pipe. At the end of an hour the squirrel was still unhurt. The lowest point of the pipe was now raised about six inches so that the vajor could spread through this length and 2% gas was again exploded. The fumes of the explosion reached the squirrel but not in sufficient quantity to affect it seriously in an hour's treatment. The pipe was again lowered so that there was eighteen inches difference in level between the two ends. A squirrel was placed at the upper end and sufficient carbon bisulfide added to make a strength of 4% gas in the air. After half an hour's treatment this squirrel began to show signs of partial collapse but at the end of an hour could still move about briskly. It was taken out at this time, but died later in the night. Another animal was treated with 4% gas which was exploded and at the close of an hour was not seriously affected. A large strong squirrel was now placed in the upper end of the pipe and two ounces of carbon bisulfide was added to an inexpensive pump machine which vaporized the carbon bisulfide and drove the gas with moderate force into the burrow. In ten minutes after the pumping began the squirrel commenced to be affected. Pumping was continued at infrequent intervals for ten minutes more. In thirty-five minutes from the time the treatment started the squrrel was dead.

The conclusion to be drawn from these experiments is that carbon bisulfide gas will flow readily on the level or down-hill. It will not in either its exploded or unexploded form rise over an elevation of even one to two feet unless driven by some form of pumping or compressed-air apparatus. This undoubtedly explains many failures under field conditions.

At the close of the carbon-bisulfide fumigations two squirrels, a large strong male and a female, were treated in the artificial burrow, with 2% Kilmol. The gas was allowed to flow from the upper end just as the 2% carbon bissulfide had and the squirrels died in twenty and twenty-one minutes, respectively, i.e., in the same time as did those treated with carbon bisulfide.

A number of queries have been received as to the possibility of using other gases than carbon bisulfide for the purpose of exterminating squirrels. These were the result of the accounts which had been published of the use of gas in modern warfare, though occasional attempts to try other fumigants have been made in the past. A great variety of gases are known to have been employed on the European battle front. The preparation of many of these is extremely com-

TABLE II.

EXPERIMENTS WITH OTHER GASES.

| Percentage of gas | Manner of use | Sex | Weight | Time of Treatment | Result |
|---|---|---|---|---|---|
| Approx. 4% gasoline | Gasoline volatilized incompletely in carboys | male | 652 g. | 43 min. | recovered |
| Approx. 4% gasoline | Gasoline volatilized incompletely in carboys | female | 435 g. | 52 min. | death |
| Approx. 2% gasoline | Gasoline volatilized incompletely in carboys | male | 652 g. | 1 hr. | unharmed |
| Approx. 2% gasoline | More completely vaporized in simple carburetor | male | 652 g. | 1 hr. | *unharmed |
| Approx. 4% gasoline | More completely vaporized in simple carburetor | male | 652 g. | 50 min. | death |
| Approx. 4% gasoline | Exploded in artificial burrow | female | large | 25 min. | unharmed |
| 2% Kilmol | Unexploded, caged, artificial burrow | male | large | 20 min. | death |
| 2% Kilmol | Unexploded, caged, artificial burrow | female | 405 g. | 21 min. | death |
| Approx. 2% carbon tetrachloride | Caged, artificial burrow | male | large | 42 min. | death |
| Chlorine | Caged, artificial burrow | female | 624 g. | 30 min. | death |
| Sulfur Chloride | Undecomposed | male | 555 g. | 2 hr. 15 min. | unhurt |
| Sulfur Chloride | Decomposed with water | male | 555 g. | 3 hrs. | partial recovery |
| ¼% sulfur dioxide | Constant stream of gas | female | large | 1 hr. | unhurt |
| 2% sulfur dioxide | Constant stream of gas | female | large | 37 min. | death |
| Arsine-calcium arsenide | | | | | |
| 2 g. | Small jar | male | large | 25 min. | death |
| 15 g. | Caged, artificial burrow | male | 701 g. | 50 min. | death |
| 7.5 g. | Caged, artificial burrow | female | 535 g. | 45 min. | death |
| 7.5 g. | Caged, artificial burrow | female | 470 g. | 38 min. | death |
| 5.0 g. | Caged, artificial burrow | female | 492 g. | 46 min. | death |
| 7.5 g. | Caged, artificial burrow | female | 414 g. | 15 min. | death after 2 hrs. |
| 7.5 g. | Caged, artificial burrow | female | 501 g. | 10 min. | death 55 min. later |
| 7.5 g. | Caged, artificial burrow | male | 164 g. | 10 min. | death after several hrs. |

* (1 day intervened after previous experiment)

plicated and expensive, and great danger would attend their use. Chlorine is probably the most readily available of those which can be employed. One great difficulty in regard to the use of chlorine is that the liquefied gas is at present put up only in large cylinders, in most cases containing 100 pounds, though a few eastern firms make 25-pound cylinders. The price recently quoted was 25 cents per pound, exclusive of the cost of the container.

As a preliminary experiment one squirrel was treated with chlorine generated on a small scale in the laboratory. The effect of the gas was evidently extremely painful and irritating, very different from the carbon bisulfide which may be slightly exciting or intoxicating at first, but later acts like an anaesthetic. The squirrel also survived for half an hour, a distinctly longer time than with carbon bisulfide, and made vigorous efforts to escape. These efforts would doubtless result in the freeing of many animals under field conditions. Chlorine is an extremely corrosive irritating gas. Its use would involve great danger to the operators as it readily attacks the mucous membrane of the throat and nose. The use of a gas under pressure from small cylinders would have several advantages as it would take the place of a pump machine, but it is not believed that this would be less expensive than carbon bisulfide.

Gasoline has had a number of advocates and has on a number of occasions been used in local campaigns. A mixture was accordingly made up in the glass carboy system which would have represented 4% of gas in the air if it had been completely volatilized. One great difficulty was observed with both gasoline and distillate, in that a considerable portion of the material does not evaporate and is therefore wasted. One squirrel was treated with this approximately 4% gas till it partially collapsed, which required 43 minutes. It was then taken out and next morning was completely recovered. A second animal was treated with the same gas till it ceased to breathe. This required 52 minutes, and it failed to revive.

An attempt was then made to devise a simple type of vaporizing carburetor, but even with this some gasoline remained as a liquid. A squirrel was treated in gas from this vaporizer and expired in 50 minutes. Two squirrels were then treated with approximately 2% gasoline vapor, one with vapor from the liquid evaporated spontaneously in carboys and the other with vapor from the simple carburetor and in each case after an hour's exposure the squirrel was entirely unharmed. As a final test a mixture of approximately 4% gasoline vapor was made up in the artificial burrow, a squirred was placed at the lower end and the gas was exploded. The squirrel was greatly

frightened but was entirely unharmed either by the explosion or by the gaseous products formed.

These experiments clearly show that gasoline is much less effective than carbon bisulfide and even with gasoline at 20 cents a gallon and carbon bisulfide at ninety, the carbon bisulfide would be the less expensive material.

Carbon tetrachloride suggested itself because its vapor is heavy and non-inflammable. A squirrel treated with it died in 42 minutes. The effect was much the same as with carbon bisulfide except that it was much less rapid. It is also a more expensive material, so that these two considerations would rule it out.

Sulfur dioxide, formed by burning sulfur has been used occasionally, but the results of the experiments heretofore reported do not warrant its application.

Sulfur chloride, a heavy unpleasant liquid formed as a by-product in the manufacture of chlorine, has been found very poisonous and unpleasant for workmen around chemical plants. The liquid itself is partially volatile and is also decomposed by water into hydrochloric acid and sulfur dioxide. Two squirrels were treated with sulfur chloride, the first with the undecomposed liquid. After two hours it was entirely unhurt. The other was subjected to the fumes formed from the decomposition of the sulfur chloride and water and in three hours' time was only partially overcome. The material was abandoned as valueless.

Dr. L. H. Duschak has suggested calcium arsenide as a possible fumigant. This substance when treated with water yields arsine, an extremely deadly gas. A sample containing 50% calcium arsenide was supplied by the Bureau of Mines and a series of squirrels treated with it in the artificial burrow. Amounts of five to fifteen grams, approximately one-sixth to one-half ounce, were used. These amounts corresponded to 3.5% to 10% of arsine in the air of the pipe. The calcium arsenide was placed in a small dish in the upper end of the burrow and an ounce of water was run into the dish through a glass tube. The decomposition of the calcium arsenide was practically instantaneous and the gas rapidly flowed to the lower end of the pipe. The arsine, unlike carbon bisulfide, is an active poison and not an anaesthetic. It does not, however, appear to attract the attention of the squirrel or cause any pain or discomfort until it produces a more or less active nausea. Where the squirrels were left in the gas continuously they died in thirty-five to fifty minutes. This is not, of course, so rapid in its action as is carbon bisulfide, but it was found that if squirrels were left in the gas for from ten to fifteen minutes

and then removed to pure air, they still died in from one to two hours afterwards. This suggests that the calcium arsenide may possibly be very effective in the field, for even if a squirrel only came in contact with the gas for a brief period of time and then escaped it would be very likely to succumb later. The calcium arsenide is the only new material which appears to be especially promising, but it is not at present on the market and will require careful trial before it can be recommended for general use.

## FIELD FUMIGATION EXPERIMENTS

At the beginning of the investigation it was found that very little exact information existed as to actual field conditions under which the fumigation has to be carried out. That is to say, nothing definite was known as to the size, depth, or extent of the burrows of the California ground squirrel. Various guesses were current that the depth of the burrow would range from two to six or more feet, and the area covered was equally indefinite. Shaw of the Washington Agricultural Experiment Station has published a series of plans of the burrows of the Columbian ground squirrel,[7] and Frandsen of Nevada similar drawings of the Oregon ground squirrel,[8] but no such work had appeared on the California squirrel.

A series of preliminary studies were accordingly made in the Berkeley hills in collaboration with Mr. Joseph Dixon of the Museum of Vertebrate Zoology, University of California. This work was later greatly extended by Dixon in the San Joaquin Valley, and observations on the Oregon ground squirrel were made by Grinnell and Jacobsen in Siskiyou County. Detailed maps of portions of this work will be published elsewhere by Grinnel and Dixon, but the essential facts derived from it are given in Table III.

TABLE III.

CUBIC CONTENTS OF SQUIRREL BURROWS

| | Length | Diameter | Sex | Cu. Contents including chambers | Result of Fumigation |
|---|---|---|---|---|---|
| Berkeley Hills | 5 ft. | 3.5 in. | male | 1.03 cu. ft. | killed squirrel |
| | 8 ft. | 4.0 in. | male | 1.40 cu. ft. | killed squirrel |
| | 14 ft. | 4.5 in. | male | 2.40 cu. ft. | killed squirrel |
| | 22 ft. | 4.5 in. | female | 4.8 cu. ft. | killed squirrel |
| Bakersfield | 34 ft. | 4.5 in. | male | 4.8 cu. ft. | killed squirrel |
| (vicinity) | 138 ft. | 4.75 in. | Colony | 17.78 cu. ft. | squirrel escaped |
| Fresno Area | 26 ft. | 5.0 in. | male | 4.6 cu. ft. | squirrel escaped |
| Oregon Ground Squirrel | | | | | |
| Siskiyou County | 66 ft. | 2.5 in. | female | 3.48 cu. ft. | no fumigation |

The great variation in length and consequently in cubic content is immediately evident. In the Berkeley hills the male burrows were found on the outer edge of the ground occupied by large colonies. These burrows were in several cases quite short, though in others they extended to a length of fourteen or fifteen feet. The greatest depth reached by the male burrows in this region was eighteen inches to two feet, while the complete female burrow examined, reached a length of twenty-two feet and an extreme depth of thirty inches. Some of these burrows were treated by the waste ball method, both exploded and unexploded, and some by pumping. In all of them the animals were found killed near the nest. The ground was level or gently sloping and therefore presented no difficulties of treatment. Under such conditions any method of treatment by fumigation would be effective.

The burrows treated by Dixon in the Bakersfield and Fresno areas of the San Joaquin Valley were in each case dosed by the waste ball method. The first one, in the vicinity of Bakersfield, was a comparatively simple male burrow thirty-four feet long. One entrance to the burrow was closed and in digging the squirrel was found some twenty feet from the entrance. On digging further it was found that there was another entrance at the other end of the thirty-four feet. This had been unobserved and was left open, but the squirrel was nevertheless killed. The ground was almost level and here again the gas had a perfect chance to flow. In the other burrow no squirrels were killed because it was a large colony burrow of greater length and with greater cubical air contents.

The burrow dug out in the Fresno area was located in the "hog wallow" country and is an excellent illustration of the extremely difficult conditions which may be encountered. The land has many layers of hardpan which are not continuous and between these the squirrel's burrow twists and turns. The side view of this burrow is reproduced here (figure 3) as it shows so clearly the problem involved. The burrow in question was treated by the waste ball method. It was then dug out and the discovery was made that the gas had not risen over "e"; the squirrel being found alive in the nest. This points to the necessity of using some form of apparatus to pump the gas. The depths of the burrows in the valley areas were found to be greater than those in the Berkeley hills where the shale subsoil tends to limit the habited zone. The greatest depth reached in the San Joaquin Valley was four to five feet, which is believed to be typical of conditions in the interior valleys.

The Oregon ground squirrel is only of importance in the extreme northern section of the state, but where found is exceptionally numer-

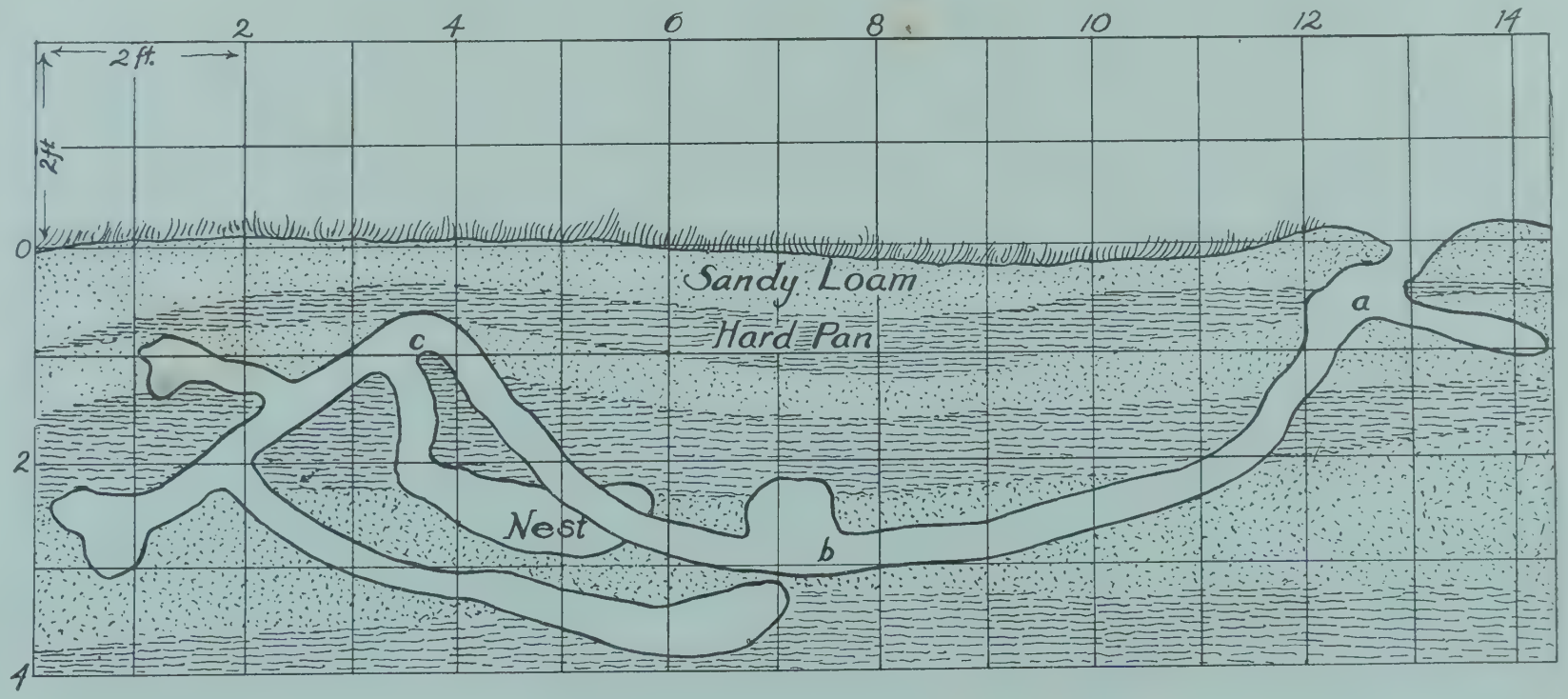



Fig. 3

Elevation of a typical burrow of the Beechey Ground Squirrel in hardpan in the vicinity of Fresno. The sudden elevation in the burrow (c) prevented the carbon bisulfide gas from the waste ball (at a) from reaching the nest. The gas, being heavier than air, settled in the intervening depression (b), without reaching the squirrel.

Contribution from the Museum of Vertebrate Zoology of the University of California. Excavations made and plotted by Joseph Dixon.

ous and prolific. It is a distinctly smaller species, as is indicated by the diameter of the burrows, which are in addition tortuous and winding.

## CONCLUSIONS

The series of experiments here described clearly shows that carbon bisulfide is an eminently satisfactory fumigant for ground squirrels. Twenty minutes' to a half-hour's treatment with air containing 2% of carbon bisulfide is certain to be fatal. The concentration of gas actually used in practice will of necessity vary with the volume of the burrow which of course is not known to the operator. The dosage of 1½ to 2 ounces usual in the waste ball method corresponds to about 2% gas in what we consider to be large burrows. The concentration in small burrows would be proportionately greater. Unless a burrow happens to be much larger than any we have found, the concentration produced with the usual dosage should be sufficient to kill in about 20 minutes, always, provided the vapor is completely diffused.

It is not suffiicient under adverse conditions to merely drop the carbon bisulfide in the burrow on a waste ball. This will produce good results if everything is favorable. When the ground is level or slightly sloping the gas will flow for twenty or thirty feet to the lowest part of the burrow. Our experiments with the artificial burrow, as well as Dixon's field observations in the San Joaquin Valley, demonstrate that the gas will not flow over elevations of one or two feet. Exploding the gas will distribute it somewhat more but not sufficiently to make it rise over the usual irregularities.

This clearly indicates that some form of apparatus to pump the gas is desirable. The commercial machines which were formerly on the market were all too expensive, ranging in price from five to twenty-five dollars. It is clear that all that is necessary is a bellows or large-bored pump which will blow a strong stream of air through the tank which contains liquid carbon bisulfide. For field work in the San Joaquin or Sacramento Valley, where it is possible to drive readily over the country, a blacksmith's rotary blower, or hand spray outfit could be connected to a vaporizing tank and mounted on a wagon with one man to operate the pump and another to fumigate. In this way great efficiency may be obtained. If a power spray outfit were adapted for the purpose it would be necessary to observe great care to keep carbon bisulfide gas away from the exhaust of the engine and avoid the possibility of a serious explosion. It is believed that any handy person ought to be able to devise a satisfactory fumigation apparatus out of materials to be found on the average ranch. Circular

181 of this station illustrates and gives dimensions of the complete squirrel "Destructor" which could be simplified in many ways.

The only difference in field procedure which is advisable when carbon bisulfide is used in a pump machine, is that the refined instead of the crude carbon bisulfide be used. This will necessitate ordering in large quantity from the wholesaler as only the crude article is usually handled by the local dealers. The price is ordinarily about the same, but the refined product will be found much more desirable for pump machines as the crude article ordinarily contains a small amount of free acid which will corrode the vaporizing tank.

It will be found necessary to vary the dose of carbon bisulfide employed depending on the nature of the country in which the squirrels are located. In foothill sections of shallow soil and hard subsoil, similar to the Berkeley hills, treatments which average half an ounce to a hole will be sufficient if a pump machine is employed. Where deep valley soils prevail and especially where large colony burrows are found it will be necessary to use two or three times as much carbon bisulfide to secure satisfactory results.

The laboratory investigations, as well as the field observations of Dixon, show that neither gasoline nor distillate are satisfactory materials for squirrel fumigation. Their effectiveness is so much lower that, as previously stated, even if 20 cents per gallon is paid for gasoline and 90 cents for carbon bisulfide the bisulfide will be found less expensive per squirrel killed. It is believed that the field has been thoroughly canvassed for possible fumigating materials, and with the exception of calcium arsenide, which will require further work to prove its possibilities, carbon bisulfide is the most satisfactory chemical so far developed.

Intelligent observation and careful work will be found to yield good results at every stage of a squirrel campaign. In the use of fumigating materials it is possible to effect great economy by treating only occupied burrows. The poisoning campaign which precedes the fumigation should have been arranged for the earliest possible date that will find the squirrels actively working in the spring. A week or ten days after the poison has been distributed a workman equipped with a mattock should go over the infested areas and close every visible hole. The fumigators should follow in one to two days. Every hole that is now open will indicate that the burrow is occupied by a squirrel and very few empty holes will be treated by this method. The treated holes will be again closed so a later inspection should clearly indicate whether any squirrels have escaped.

It is too much to expect complete eradication of all squirrels in

any one or two seasons' work. California is too widely infested with ground squirrels for such a thing to be possible. A few squirrels will escape in gullies or dry washes. Even under the best possible conditions we must face the necessity of squirrel control just as the orchardist faces an annual outlay for spraying or fumigation. The encouraging thing about squirrel control is that the work will become less and less if it is intelligently performed and thus pay larger and larger returns on the time and materials invested.

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# A STUDY OF THE EFFECTS OF FREEZES ON CITRUS IN CALIFORNIA

BY

H. J. WEBBER AND OTHERS

I. A STUDY OF THE FREEZE OF 1913 IN CALIFORNIA

By C. S. Milliken, A. R. Tylor, W. W. Bonns, and H. J. Webber

II. CHANGES THAT TAKE PLACE IN FROZEN ORANGES AND LEMONS

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III. A TEST OF THE EFFICIENCY OF ORCHARD HEATING

By A. D. Shamel, L. B. Scott, and C. S. Pomeroy

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# A STUDY OF THE EFFECTS OF FREEZES ON CITRUS IN CALIFORNIA*

By H. J. WEBBER AND OTHERS

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## INTRODUCTION

The recent injury to the citrus industry caused by the severe cold weather of the first week in January, 1919, has again emphasized the importance of having available for the use of growers data on the effects of such freezes as a guide in handling injured fruit and trees. Following the great freeze of January 5 to 7, 1913, a frost damage survey was organized by the College of Agriculture under the direction of the Citrus Experiment Station and much valuable material was collected. This information has been summarized and is published in this bulletin with the belief that it will be of service to growers in handling the problems connected with this winter's freeze.

Much of the data presented and the methods suggested are applicable to any freeze, but some of the matter presented has historical value only. The section on "Protection by Artificial Heating" will be recognized as not being up to date. Even this section of the bulletin, however, is believed to be of value, as it is a record of achievement in the "big freezes" with what would now be considered very inferior equipment. If growers succeeded so well with inferior equipment it would seem certain that a grove, with modern equipment, could be perfectly protected in another freeze of equal severity. To delay the publication until such sections could be brought thoroughly up to date would make its publication too late to be of any serivce in the present freeze.

This bulletin, then, is really a record of the freeze of 1913. While there had been freezes in preceding years, in which citrus fruits and various subtropical plants were somewhat injured, nothing so severe and disastrous as this freeze had occurred in the state since the citrus industry was started.

Aside from the general field studies and observations, special studies were made on the chemical and physical changes that took place in the deterioration of frozen fruits. It is the purpose of this bulletin to discuss such of the studies as it is thought will be of interest and value to growers, in case of future freezes. No attempt will be made to compare the relative degree of damage done to groves in various sections, as it is thought that the conditions shown in this freeze might be reversed or much changed in another freeze, and such comparisons might thus be misleading.

Messrs. A. D. Shamel, L. B. Scott, and C. S. Pomeroy, of the U. S. Department of Agriculture, coöperated with the Experiment Station

in making certain observations on the effectiveness of artificial heating, and their findings are reported in a special article in this bulletin.

Many growers in various parts of the state, too numerous to mention individually, have also greatly assisted our investigators and have given freely of their time and experience. To these and to all who have aided in the preparation of this report I wish to express the thanks of the institution.

H. J. Webber,
Director, Citrus Experiment Station.

Fig. 1.—Badly frozen Eureka lemon grove. Leaves still hanging but drying out. Photographed by Smith, March 7, 1913. (See same grove later in fig. 2.)

# A STUDY OF THE FREEZE OF 1913 IN CALIFORNIA

By C. S. MILLIKEN, A. R. TYLOR, W. W. BONNS, and H. J. WEBBER

## METHODS OF INVESTIGATION

In gathering the data for this report a large number of the citrus groves in different districts of southern California were visited.

In making the observations several trips were necessitated to various sections in order to determine the final effects of different methods of treatment. Wherever an interesting case or experiment was found, the observer continued to follow the recovery of the trees until the full effect of the treatment became apparent. One of the writers of this article made similar extended observations following the great freeze of 1894–95 in Florida* and in this article frequently a comparison of the conditions and methods of treatment has been made.

The conclusions which have been drawn are based upon numerous observations, and these have been made in a number of different districts by many different observers. While it is possible to find exceptions to most rules, the value of the rules is not destroyed by the exceptions, and so in this summary of the effects of the freeze, an attempt has been made to state those things which as a rule were found to prevail, believing that the clearest record of conditions can be given in this way.

## GENERAL AND METEOROLOGICAL OBSERVATIONS

The freeze began Sunday, January 5, 1913. Unlike visitations from frost in previous years, the Sunday cold was accompanied by a strong wind. Somewhat different conditions prevailed in different places. The following are the conditions as noted at the Citrus Experiment Station. Sunday, January 5, was a cold day throughout. Ice three-sixteenths of an inch thick was observed in the street about noon, toward evening the wind went down, and between 7 P.M. and 11:30 P.M., the coldest period, there was scarcely any movement of air. The temperature during this period, at a point about 300 feet to the east of the grove, remained between 15° and 18° F. (Compare Chart I).

* Webber, H. J., The Two Freezes of 1894–95 in Florida, and What They Teach, Yearbook, U. S. Dept. Agr., 1895, pp. 159–174.

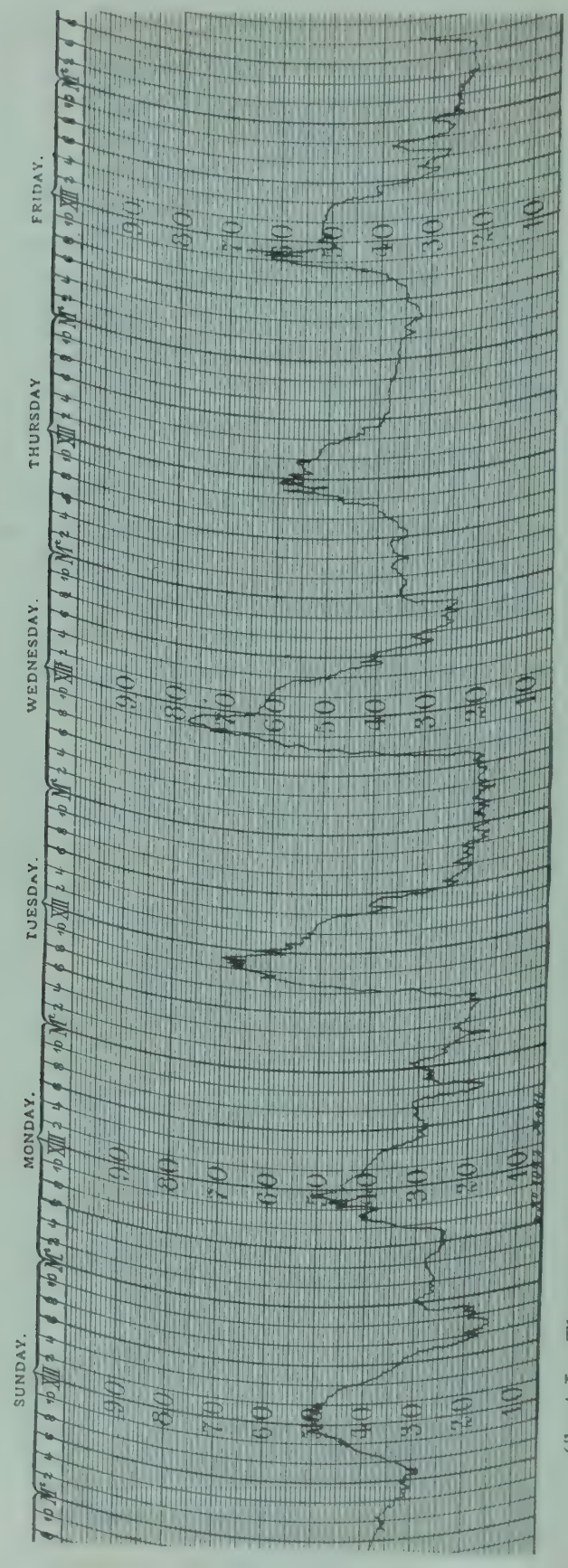



Chart I.—Thermograph record at the Citrus Experiment Station, Riverside, Cal., for the period from Sunday, January 5, 1913, to 6 A.M. Saturday, January 11, 1913.

In general throughout the citrus belt the Sunday night cold was accompanied by a strong wind that blew throughout the night. By Monday night, January 6, the wind had died down, but the cold was unabated; and on Monday night and Tuesday morning the temperature went lower than it had gone the night before. Tuesday night and Wednesday morning were also cold, sufficiently so in most of the citrus districts to freeze fruit. After this, the temperature became more moderate, although for several days the skies were cloudy and the weather stayed cool. On the 9th and 10th, there were light rains in most sections and heavier rains about the middle of the month. The month of January as a whole was the coldest January for fifteen years; while the cold spell from the 5th to the 8th was the coldest weather ever experienced by citrus growers in southern California.

Heretofore cold spells have usually occurred on still, cloudless nights. On such nights the air becomes stratified, the colder strata resting on the ground. A breeze improves the temperatures at such times by mixing the strata of warm air with those of colder air. The freeze of 1913, however, was very different from previous periods of cold. It was preceded by strong winds which came from the northwest and north. Mr. A. G. McAdie, of the United States Weather Bureau, has called attention to the fact that the winds preceding frosts in California usually come from the northeast. He points out that this year the cold wind came from the north and northwest, moving directly over the Sierra Madre Mountains, with their elevation of six thousand feet, instead of taking the customary course through the El Cajon Pass.

The temperature records reported from various places are in general so inaccurate that little dependence can be placed upon them. The Weather Bureau records are thus the best ones that can be taken for comparison. True, these records do not represent grove records, but they are at least comparative for different places. The following table supplied by Dr. Ford A. Carpenter, in charge of the Los Angeles Observatory, U. S. Department of Agriculture, Weather Bureau, gives the maximum and minimum records for the period of the freeze for various points in California.

The minimum temperatures reported from the different parts of southern California show a range from 25° F. to —2° F. The accuracy of these extremes may well be questioned. It may safely be concluded that most citrus districts reached a temperature as low as 18° F. Several places have reliable records as low as 15° F., and a few places show apparently reliable records as low as 12° F. In many sections the temperature remained at or below freezing for sixty hours.

TABLE 1.—MINIMUM AND MAXIMUM TEMPERATURES, JANUARY 5 7, 1913, IN VARIOUS PARTS OF CALIFORNIA

| Stations | Minimum temperature | | | Maximum temperature | | |
|---|---|---|---|---|---|---|
| | 5th | 6th | 7th | 5th | 6th | 7th |
| Azusa | 25 | 22 | 20 | 48 | 49 | 54 |
| Bakersfield | 28 | 16 | 14 | 52 | 49 | 40 |
| *Beaumont | 20 | 16 | 24 | 25 | 32 | 38 |
| *Chino | 30 | 28 | 16 | 44 | 42 | 44 |
| Claremont | 27 | 25 | 19 | 47 | 42 | 49 |
| *Colton | 28 | 27 | 19 | 42 | 35 | 47 |
| *Duarte | .... | 28 | 28 | .... | 45 | 46 |
| El Cajon | 30 | 20 | 21 | 52 | 46 | 54 |
| Escondido | 32 | 15 | 13 | 56 | 42 | 45 |
| *Exeter | 17 | 17 | 19 | 54 | 52 | 51 |
| Fresno | 24 | 17 | 20 | 39 | 39 | 44 |
| Lemon Cove | 22 | 18 | 20 | 65 | 52 | 56 |
| Los Angeles | 36 | 30 | 28 | 49 | 47 | 50 |
| Monrovia | 28 | 24 | 18 | 50 | 45 | 50 |
| Pasadena | 31 | 25 | 21 | 47 | 43 | 50 |
| Pomona | 25 | 21 | 18 | 48 | 43 | 51 |
| Porterville | 22 | 20 | 18 | 41 | 46 | 48 |
| Redlands | 31 | 22 | 18 | 42 | 36 | 50 |
| Riverside | 30 | 21 | 22 | 48 | 41 | 55 |
| San Bernardino | 31 | 26 | 18 | 46 | 35 | 53 |
| San Diego | 36 | 28 | 25 | 47 | 45 | 49 |
| Three Rivers | 28 | 17 | 16 | 40 | 39 | 44 |
| Ojai Valley | 28 | 13 | 13 | 49 | 50 | 55 |
| Santa Barbara | 28 | 27 | 30 | 52 | 44 | 58 |
| *Tustin (Irvine Ranch) | 48 | 32 | 34 | 70 | 50 | 56 |

At stations marked (*) the minimum temperatures were taken at 7 A.M., and are probably not so low as the true minimum. The maximum records of these stations were taken at 2 P.M., and are probably lower than the true maximum.

Frosts during the winter months are not uncommon in southern California, and it often happens that a certain amount of loss of fruit results from low temperatures, especially in low places where the citrus area has been extended out beyond its adaptable sphere. Abbot Kinney in his book on Eucalyptus refers to an unprecedented frost in 1893. In 1898 in certain sections, severe damage was experienced, and again in December, 1912, a very heavy frost occurred, but the freeze of January, 1913, was probably more severe and widespread than any ever experienced here within the memory of white man.

Maximum and minimum thermometers, although of much greater value and satisfaction than the ordinary instruments, are in themselves of little real value, unless it is possible to compare these recorded temperatures with the story as pictured by thermograph records taken

in the same vicinity, for the actual minimum temperature means but little in regard to the resulting effects upon plant life, unless the duration of the low temperature, as well as the actual minimum, is also known. Lemon trees subjected to a temperature of 20° to 22°, but of very short duration, were not injured; while the much more hardy orange trees, experiencing a similar low temperature that continued for nine or ten hours on three successive nights, were entirely defoliated.

Fig. 2.—Badly frozen Eureka lemon grove two months after the freeze. The same trees as those shown in fig. 1, but three months later. Photo by Smith, June 24, 1913.

The elevation of groves above sea-level does not indicate their liability to frost injury. Citrus fruits in southern California are grown at elevations ranging from sea-level to twenty-seven hundred feet or more; and while in some sections trees at sea-level suffered severely from the January freeze, and groves at 1400 and 1500 feet were unharmed, in other sections the reverse conditions occurred.

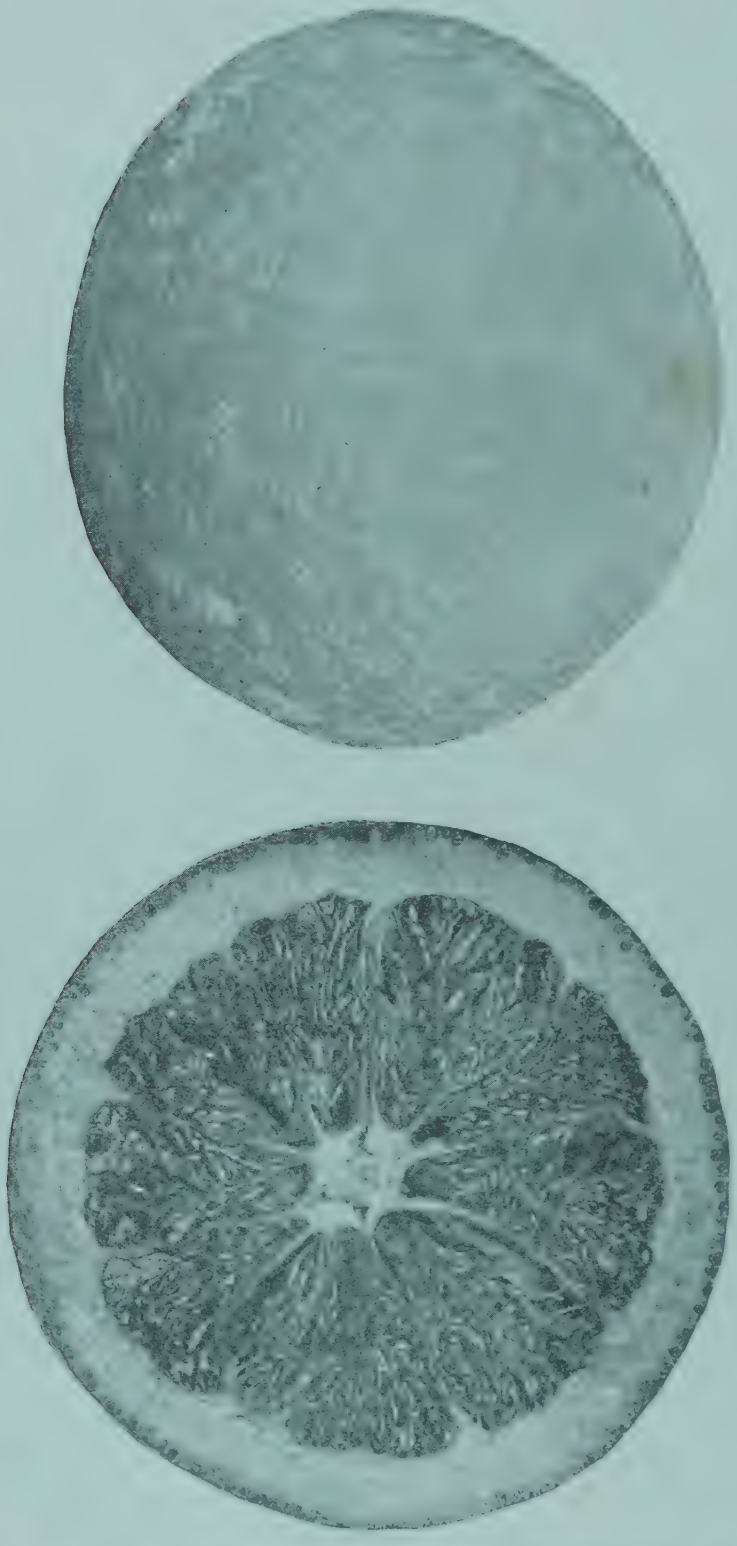


Fig. 3.—Frozen Valencia oranges showing characteristic spots on surface and the breaking down of the interior, accompanied by thickening of the skin. Photo by Smith.

## THE EFFECTS OF THE FREEZE ON CITRUS TREES AND FRUITS

*Effect on Citrus Trees.*—One of the first noticeable effects of the cold weather upon citrus trees was the formation of ice in the fruits. The ice formed earlier in lemons than in oranges, and at the same temperature lemon fruits were frozen much firmer than oranges. At

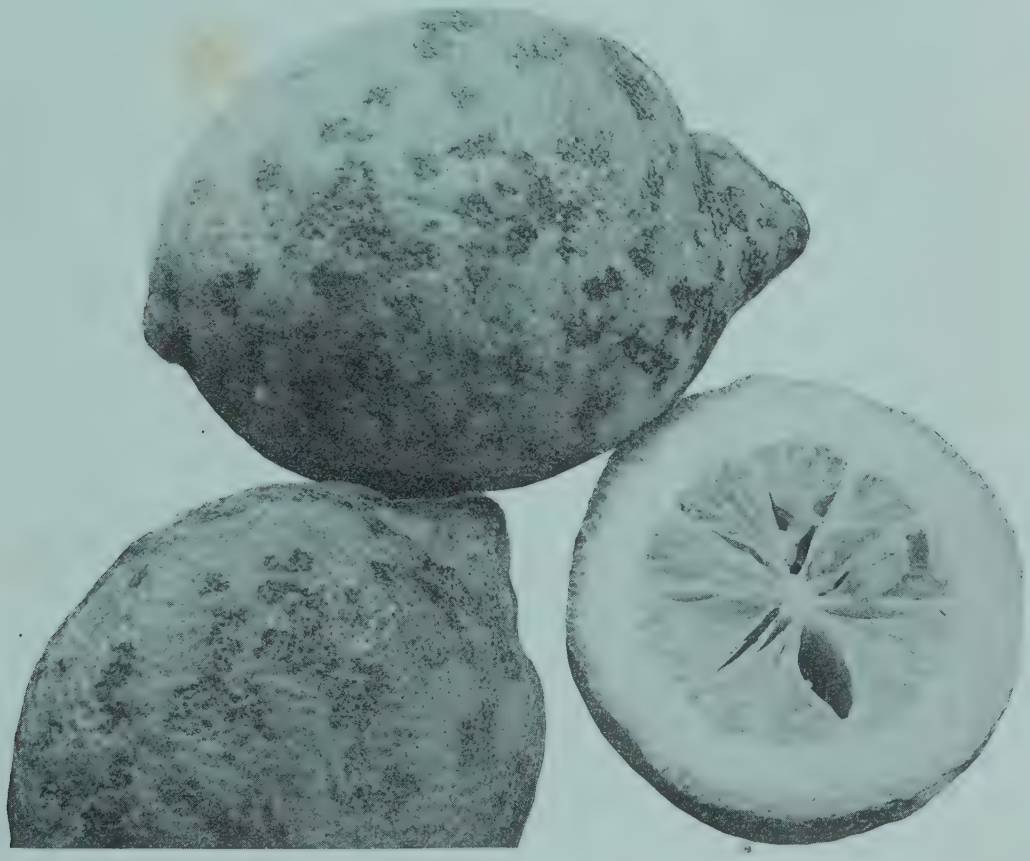


Fig. 4.—Lemons showing characteristic external spotting of fruit and breaking down of tissues caused by freezing. Photo by Smith.

temperatures at which lemons were frozen so that they were solid, juiceless and brittle, oranges could be pressed out of their natural shape and some juice could be extracted.

Another effect of the low temperature which made a conspicuous change in the appearance of the trees was the curling of the leaves of the orange trees during the cold. This curling of the leaves, which did not occur on the lemon trees, gave to the orange trees a sort of deathly aspect. It was commonly remarked by growers that the orange trees seemed to be affected worse than the lemons, and many

growers were prepared to believe that another of the unusual things so usual in California had happened and that lemon trees had been less injured than orange trees by the cold. In a few days, however, the leaves of the lemon trees began to droop and turn brown; while the orange leaves, where the temperature did not go too low, unrolled and assumed their normal functions. Due to the slow physiological changes in both fruit, foliage and wood following the freeze, it was some time before accurate indications of the extent of damage became visible.

*Effect on External Appearance of Fruit.*—The orange and lemon fruits, while still frozen, often showed in the skin clear, icy areas adjoining other areas which were not icy. A few days after the freeze these fruits became spotted (figs. 3 and 4), caused by a shrinking of the tissue between the oil-bearing cells and a consequent drawing together of these more deeply-colored, oily portions of the skin. Soon after the freeze lemons which were frozen very hard were covered with white watery patches, which gave them a loathsome appearance. A black mold frequently established itself on these fruits and they shriveled and dried up on the trees.

The degree to which fruit becomes spotted gives a good, early indication of the severity with which it is damaged, especially with oranges. If none of the oranges in a grove are spotted, the fruit may have been injured, but usually there still will be fruit of value in the grove. Where the freezing has been harder, spotted fruit will show on the north side of the tree, and to some extent, there will be spotting on the north side of fruit on the south side of the tree. The stem end seems to be most easily spotted. In groves where north side spotting is general, there is little fruit which will not show signs of deterioration by the time three months have passed. The fruit which is spotted is valueless, for though it may retain juice for some time, it deteriorates so rapidly that it does not pay to ship it. Where the fruit in all parts of the tree is spotted, but little value can be attached to the crop.

All citrus fruits are not subject in the same degree to this frost spotting. The tangerine apparently is not subject to it and the Valencia, while sometimes found badly marked, is much less susceptible than either the navel or the Ruby Blood. Both the pomelo and lemon are readily marked with these frost spots, the former fruit, when exposed, being especially susceptible. The frost spots of both the pomelo and lemon in time turn brown and become far more conspicuous on the yellow background of these fruits than the yellow spots of the orange on the orange-colored background of that fruit.

*Effect on Internal Condition of Frozen Fruit.*—One of the earliest internal indications of frost damage in citrus fruits is the formation in the membranes or pulp of small white spots or crystals of hesperidin. In oranges, lemons and grapt fruit these are found on the membranes between the segments (fig. 5). In tangerines where they are very conspicuous they are scattered throughout the pulp. These white spots

Fig. 5.—White spots, hesperidin crystals formed in the membranes of the Washington Navel orange as a result of freezing. One of the most characteristic symptoms of cold injury. Photo by Smith, February 8, 1913. (Somewhat enlarged.)

can be found in from five to ten days after the freezing and can best be seen by cutting the fruit transversely and tearing the segments apart.

When frozen oranges are cut transversely they often show a pale area part way between the center of the fruit and the skin. Frozen lemons are somewhat more opaque than uninjured fruit. In all varieties the pulp cells of frosted fruit tear apart more easily when cut across than is the case with unfrozen fruit.

When a month or so has elapsed after the freezing, the segments of fruit begin to pull apart because of the drying of the frozen tissue (figs. 3 and 4). This condition is best seen in cross-section. It shows first in fruit which was exposed to the morning sun where it may appear within ten days after the freezing. Sometimes, especially with fruit inside the tree, this breaking down may not begin for three months.

*How to Determine the Extent of Fruit Injury.*—It is frequently of importance soon after a freeze to be able to determine the extent of the fruit injury. The external and internal character shown by frozen fruit are given in the preceding sections.

Another method of recognizing fairly quickly the good from the frozen fruit was found in the changes in specific gravity that took place in fruits that were picked and stored. Good fruit increases in specific gravity by the drying out of the skin causing a decrease in volume without much loss of the interior juices. Frozen fruit, however, rapidly decreases in specific gravity as the interior juices pass out into the skin readily, and are evaporated without producing much change in volume.

In an investigation conducted by Professor John S. Burd and Mr. W. H. Dore of the College of Agriculture it was found that these changes could be greatly hastened by picking and storing the fruit in a warm atmosphere. The following statements prepared by them will show the possibilities of this method.

The following typical data illustrate the relative changes in specific gravity of unfrozen and frozen fruit over several time intervals when stored in a cool room. The figures in every case represent the average of a number of individuals.

FRUIT STORED IN COOL ROOM

| | Initial | After 4 days | After 8 days | After 16 days | | |
|---|---|---|---|---|---|---|
| Unfrozen oranges | 0.857 | 0.865 | 0.876 | 0.894 | Maximum 50 days | 0.951 |
| Frozen oranges | 0.838 | 0.836 | 0.828 | 0.787 | After 40 days | 0.689 |
| Unfrozen lemons | 0.942 | 0.955 | 0.967 | 0.981 | Maximum 50 days | 1.023 |
| Frozen lemons | 0.806 | 0.747 | 0.615 | | | |

When sound and frozen fruit are stored in a room at a temperature of 95° F., the specific gravity changes are similar in character to those observed in the cold room fruit, but the rate of change is about three times as great in the warm room as in the cold, as shown in the following data.

FRUIT STORED IN WARM ROOM

| | Initial | After 4 days | After 8 days | After 16 days |
|---|---|---|---|---|
| Unfrozen oranges | 0.848 | 0.874 | 0.920 | 0.926 (Maximum) |
| Frozen oranges | 0.842 | 0.842 | 0.816 | 0.729 |
| Unfrozen lemons | 0.943 | 0.979 | 1.006 (Maximum) | |
| Frozen lemons | 0.811 | 0.691 | | |

The absence of change in the first interval in the case of the frozen oranges is due to the fact that a gain in specific gravity in some individuals counterbalanced a corresponding loss in others. After the first four days nearly all individuals showed a decrease.

By picking separately a quantity of fruit from different parts of an injured grove and different parts of certain trees, and storing it in a warm dry room at a temperature of from 85° to 100° F. within six to ten days the changes have become marked and an examination will enable an accurate estimate to be made of the damage.

*Effect on Quality and Uses of the Fruit.*—Oranges that were frozen sometimes developed a bitter taste after the freeze. This, however, was by no means universal, and later this bitterness disappeared. Even when no bitterness was produced the flavor was affected, becoming gradually less rich. No harmful ingredients developed, however, and the oranges were very generally eaten so long as they remained juicy and palatable. So much was said immediately after the freeze regarding the possible injury to health that might result from the eating of frozen fruit that this point should be strongly emphasized. In California and Florida and indeed in practically every orange country, frozen fruits have from time to time been used in large quantities without injury. The evidence on this matter is so extensive that we may conclude, without fear of contradiction, that under all ordinary conditions frozen fruit may be eaten with the same impunity as normal, unfrozen fruit. So long as the frozen oranges remain juicy and palatable they may be considered as a wholesome article of food.

*Effect on Foliage.*—The fruit of citrus trees is more tender than other parts of the trees with the exception of the tender young growth (fig. 6). Next to the fruit in tenderness are the leaves and then the wood. There were areas during this freeze where all of the fruit on lemon trees was frozen and the trees still retained 50 per cent or more of their foliage. Many acres of orange groves had all of the fruit frozen without any loss of matured foliage.

*Effect on Wood.*—Young trees, of course, suffered more than older trees, and young parts of trees more than older parts (fig. 6). The parts of the bearing trees that had been of faster growth were injured

much more readily than the parts of the trees that had attained their size more slowly. This is probably the explanation of some of the freakishness noticed in trees where one branch of the tree was killed and the rest of the tree remained undamaged.

A case illustrating this point may be cited, where a navel orange tree showed no signs of injury except on one branch, and this branch was killed. On careful inquiry, it was found that a year or two before

Fig. 6.—Valencia orange tree in foreground on which the young rapidly growing branches were all killed. The mature foliage on the older trees in the background was but slightly injured. The fruit on trees showing such injury is certain to be a total loss. Photo by Smith, January 24, 1913.

a branch on this side of the tree, which was particularly heavy with fruit, was twisted and broken during a strong wind, so that it had to be cut out, leaving a large hole in the side of the tree. A new sprout grew out near the base of the cut branch, and it was this rapidly-grown branch that was frozen.

*Effect on Bark.*—After the freeze, many of the trees showed a splitting and loosening of the bark. This was especially common on lemon trees, but occurred also on orange and grapefruit trees, where the temperature went sufficiently low. Sometimes the bark split even when the foliage was not damaged, and cases were reported where the

bark on limbs had been split, and the fruit on these limbs had not been noticeably injured.

The loosening of the bark in most cases signified the killing of the cambium layer, but this was not always the case, because several months after the freeze, it was common to find bark, which had loosened along one edge but which had continued to live and grow, forming a new layer of wood (fig. 11). One tree was found where a strip of bark had completely separated from the tree, forming a bridge. The bark was alive and had developed a layer of wood and a new bark had formed next to the tree.

The most surprising feature in connection with the severe bark splitting on the trunks has been, in many cases, the comparatively slight injury to the tops and foliage. Often there was bark splitting when there was but little frost damage to either fruit or foliage.

Some lemon groves of large old trees were observed that showed much cracking and checking on the limbs and trunks, where similar, adjoining groves, apparently as severely injured, showed almost no checking.

While it is true that in most cases where the bark was split and loosened from the tree it was killed, it does not follow that when the bark was killed it always loosened. Instances were common where trees were girdled with frozen bark and the bark remained perfectly tight. Sometimes these girdled trees showed no foliage damage and there would be no suspicion that they had been injured until suddenly, perhaps four months after the freeze, the leaves would droop and the tree would die.

In Florida the area of bark immediately around the bud-union is very susceptible to injury by freezing, being more tender than the bark on other portions of the trunk. This greater tenderness of the bud-union was not noticeable in California, the bark on the other portions of the trunk being injured just as readily as around the bud-union. In California the point most susceptible to injury seems to be in the crotches of the limbs.

## RELATIVE HARDINESS OF DIFFERENT VARIETIES AND SPECIES OF CITRUS FRUITS

*Relative Hardiness of Trees.*—The freeze brought out marked differences in the hardiness of the several varieties of citrus trees grown in California. It also demonstrated that the relative hardiness of the trees of a variety is not the same as the relative hardiness of the fruits of that variety, and this fact must be borne in mind in order to avoid confusion.

Orange trees, of course, proved themselves much hardier than lemon trees. It was common to see lemon trees entirely defoliated, and among them orange trees which had lost few or none of their leaves. There were other places where the lemon trees were partly defoliated and had split bark in the limbs, while the orange trees showed no damage except in the fruit, and even here the damage was so limited that the grower received good returns for his crop.

In most places there seemed little difference in hardiness between Washington navel trees and Valencias, this being especially true of the bearing trees.

In one locality, where there was not much damage to the bearing orange trees, a careful comparison was made between the condition of 250 young Valencias and the same number of navels. These trees were all of the same age, two years and a half old at the time of the freeze, and offered an opportunity for a perfectly fair comparison. Fourteen per cent of the navels and 3 per cent of the Valencias had the limbs killed; 64 per cent of the navels and 93 per cent of the Valencias were largely defoliated without having the limbs killed; 22 per cent of the navels and 4 per cent of the Valencias were only partially defoliated. In this case the navels were not less hardy than the Valencias, but the amount of variation was greater in the navels. More navels than Valencias were badly frozen, but there were also more navels than Valencias among the trees which were only slightly injured.

The conflicting degrees of injury exhibited by these varieties in different places indicate that they are naturally of about the same degree of hardiness and that the differences observed in different places were due to the varying condition of the trees at the time of the freeze.

There was a marked difference in the hardiness of the two principal varieties of lemons, the Lisbons showing themselves decidedly more resistant than the Eurekas. Temperatures low enough to cause Eureka trees to drop three-fourths of their leaves were withstood by Lisbons with practically no foliage damage and with some uninjured fruit. Villafranca lemons proved somewhat hardier than Eurekas, but not so hardy as Lisbons. In one nursery two-year-old Eureka and Villafranca trees on sweet stock were found side by side. The former trees were frozen nearly to the buds, whereas only the upper half of the Villafranca tops were killed.

The grapefruit trees proved more hardy than lemon trees. The fruit of the pomelo is never so easily frozen as the orange fruit, but

the trees usually showed themselves somewhat more tender than orange trees.

Among the other varieties of citrus trees the tangerines and the Satsuma oranges were more hardy than the navels and Valencias. The tangerine tree is very resistant, and many cases were found where this tree retained its foliage alongside of orange trees that had been entirely defoliated. Only two groves were found containing King orange trees, and in both of these instances they were more seriously injured than near-by navel orange trees.

Lime trees were more tender than lemons, the Tahite lime being more hardy than the Mexican. The citron was slightly more tender than the lime. Several instances were observed where lime and citron trees were growing in lemon orchards; and in such cases they were entirely defoliated and a portion of the brush or tops killed alongside of lemon trees that merely lost the outer layer of foliage.

When one considers that the citrus tree is a native of the tropics, it is surprising to find it capable of standing the temperatures of the 1913 freeze. In one place young navel orange trees, that were subjected to a minimum temperature of 5° F. above zero, came through with trunks alive, notwithstanding that the navel orange was brought to the United States from a place only 12 degrees south of the equator.

*Relative Hardiness of Fruit.*—The fruit of the pomelo was less injured by the cold than any other of the citrus fruits. Even when the skin was spotted as a result of the freezing the inside pulp often showed no breaking and remained juicy. In this respect the pomelo was quite different from the orange, because there was always a noticeable injury to the pulp of oranges which had spotted skin.

The comparative injury of navel and Valencia fruits varied with the locality. In many sections there seemed to be little difference in the condition of the two kinds of fruit, but where there was a difference, it was more common to find the injury greater in the Valencias. As the Valencia is the later variety, the fruit was less mature at the time of the freeze than were the fruits of the navels. In Whittier, and in the Sespe Cañon in Ventura County, the Valencia proved to be more hardy than the Washington navel. The Thompson Improved navel proved more tender than the Washington navel or the Valencia. Blood oranges ranged about the same as Washington navels.

Although the tangerine trees are so hardy, their fruit is more easily frozen than the fruits of the navel and Valencia.

Lemon fruit is injured at a temperature several degrees higher than that which injures oranges, and of course the young, small-sized lemons are more tender than those which are large enough to be picked.

It has been supposed that lemons can withstand a temperature of 28° F. without injury, but whether the crop of small fruit can be exposed to this temperature without loss has never been determined with sufficient accuracy to be convincing. The tendency among the best orchardists is to regard any temperature below 32° F. as dangerous.*

Lisbon fruit was less easily damaged than that of Eurekas. The difference did not seem to be due entirely, at any rate, to the heavier foliage of the Lisbons, because the fruit of the heavy foliage type of Eureka was injured more than the Lisbon fruit.

Yellow or tree-ripe lemons were more sensitive to frost injury than either the large-sized silver or green fruit. The packing-house reports from one young grove showed practically no loss of the large-sized green fruit, and only 15 per cent frozen fruit in the silver; while the tree-ripes were a total loss. This comparative resistance between the yellow or tree-ripe and the green fruit was found to be quite general.

## NATURAL FACTORS INFLUENCING THE TEMPERATURE

*Elevation.*—Comparative elevation is a very important element in influencing temperature. It was common to hear people remark, soon after the freeze, that it was colder this year on the higher levels than it was on the lower ground; but this was not generally so. Investigation showed that as usual the lower portions of most districts were colder than the higher land of those districts. There were many places where this advantage of the higher ground was clearly illustrated in a single grove. In such groves a gradual transition could be seen from the uninjured fruit and foliage of the higher portions to entirely defoliated trees below.

It must be understood that it is, in all cases, the relative elevation that is important, not the actual elevation above sea-level. An adjoining low area, valley, or arroyo that afforded opportunity for the cold air to drain off was in this freeze, as in other freezes, of decided advantage.

There were some places, nevertheless, where, contrary to the relations existing in most years, the damage on the higher ground was greater than farther down the slope. In Upland this was shown by the condition of the street trees, the pepper trees at the top of the hill being defoliated and those lower down showing only slight damage.

* Compare article on "Recent Investigations in Orchard Heating," by I. G. McBeth and J. R. Allison, The California Citrograph, January 1919, p. 51.

*Protective Hills.*—The damage done by freezing was closely correlated with the injury done to the trees by the severe wind.

It was probably on this account that plantings which were sheltered on the north by hills passed through the cold wave in much better condition than areas that received the unintercepted blast from the north. It looked in many cases as if the hills were so located that a body of warm air had been locked in around the trees, and that the cold north wind had slipped over these pocketed areas.

Again, the presence of a mountain range along the south side of certain sections apparently accounts for the little injury to fruit, probably due to a more gradual thawing of the fruit so situated. In still other sections there appeared to be no frost high-line, and the higher orchards, located along a north slope, appeared to be as severely injured as the lower orchards.

*Influence of Cañons.*—In previous years the territory about the mouths of cañons has usually been favored during cold weather. The current of air coming down the cañon has kept the air well mixed and prevented the stratification which takes place when the air stagnates. This year it seems that the whole mass of air, which moved down over the mountains, was below the freezing temperature, and cold air in motion is much more damaging than quiet air of the same temperature, so that many of the cañons this year changed their nature. This was not universally true, for there were some cañons which gave no evidence of being sources of streams of cold air. The groves nearest to the San Gabriel Cañon, for instance, were not damaged so much as groves farther out in the valley. The San Antonio Cañon, on the other hand, was very cold, judging by the appearance of the groves near its mouth. The San Antonio Cañon takes the same general north and south direction as that of the wind which ushered in the cold, while the San Gabriel Cañon runs northeast and southwest in its lower portion and nearly east and west in its upper forks.

*Water Protection.*—The protection afforded by nearness to bodies of water of considerable size, which was shown to be of very great importance in Florida, where there are many lakes and inland bays, was of very little importance in California. In a general way the less injury to trees near the coast may in a measure be due to the modifying influence on the cold, exercised by the nearness of the ocean. Doubtless nearness to the ocean failed to give any very marked indication of water protection, primarily because the wind accompanying the freeze was from the landward side.

*Protection Afforded Fruit by Location on Tree.*—The location of fruit on the tree frequently exercised an influence on the damage

produced. When fruit happened to rest upon the ground it usually remained uninjured, even when all of the rest of the fruit of the tree was frozen so that it soon became juiceless. Because fruit which touched the ground was so protected it does not follow that fruit which was near the ground was less damaged than fruit higher in the tree. The reverse was usually the case.

While there was no advantage to the fruit in being near the ground, it did receive some protection when tucked in among the leaves of the tree. One of the most promising sections of an orange tree on which to find fruit good to eat was in the foliage on the south side of the tree. Fruit in this position on the tree very likely passed through more gradual changes in temperature both in freezing and in thawing than fruit in more open situations.

## ARTIFICIAL METHODS OF PROTECTING GROVES

Along with the natural modifying agents of the temperature, such as elevation, hills, and cañons, there were a number of artificial causes which modified the cold. The most important of these was the heating which was done in so many groves. Windbreaks, running water, wrapping of the trees, and lath covering are things which must also be considered.

*Windbreaks.*—The question of windbreaks, their benefit, and detriment, and the comparative value of different trees for such purposes, has been for many years a constant source of discussion. The ideal windbreak seems to be the Monterey cypress and the blue-gum planted alternately in one row, the trees set five to six feet apart. In such windbreaks the cypress forms a tight base and the Eucalyptus gives the desired height.

The tendency during the past few years in many sections has been to remove windbreaks, for they have served in some places to prevent air drainage, and increase the damage from frosts, where their need as wind shields was not important. There are other sections which are annually visited by strong winds where they are rightly regarded as indispensable.

In most groves the three or four rows on the leeward side of the windbreak were less injured by the freeze than those in other parts of the orchard, but it was rare to find any frost protection more than five rows away from the hedge. It is not clear that all of this protection was due to the modifying of the temperature by the windbreak, as the orchard rows next to the windbreak are frequently much

drier than the other trees of the grove, as is made evident by the lighter crops on these rows, and this puts these trees in a different condition to resist cold. It has been found that trees that were dry, provided they were not actually suffering and weakened because of drought, were less easily damaged by the cold than trees which had a more plentiful supply of sap or were in more active growth.

A few groves were found where the rows next to the windbreak had been kept in practically as good condition as the other trees of the grove by giving them extra water and fertilizer. In some of these groves it was also possible this year to notice a slightly better condition of the rows next to the windbreak.

It seems certain from all of the evidence collected that windbreaks did exercise a distinctly modifying effect in this freeze on the damage caused to the trees for a short distance to the leeward of them; but this advantage was slight, and, in view of the rareness of the occurrence of such severe freezes accompanied by wind, it would not, as a whole, seem wise to advocate the use of windbreaks for frost protection only. They take up much valuable space and when the temperature is that of a "frost" rather than a freeze the protection that the windbreak gives to the leeward side is likely to be offset by the increase in damage on the windward side.

*Effect of Running Water or Irrigation During Freeze.*—One of the first methods of protection to suggest itself to growers was to run water through the grove. The water would have to give up much heat in being cooled, and if water freezes a large amount of heat is released.

When conditions were such that all the factors were the same except for the presence of running water, the groves that were under water sometimes looked better than those which were not.

In one grove only 5 per cent of the fruit (navels) from that portion of the orchard which was irrigated during the cold was rejected at time of shipping, whereas 100 per cent of the fruit from the non-irrigated portion was frozen. Other conditions were apparently similar. The fruit was picked some time previous to March 28.

In three citrus nurseries well defined benefit from running water during the freeze was apparent, and one small orchard of 500 one-year-old Valencia trees was found where one-half of the trees had been irrigated during the entire cold spell from Sunday afternoon until Wednesday morning. Ten per cent of the non-irrigated trees were killed and the outer layer of growth on the remaining 90 per cent was badly injured, while the irrigated trees showed practically no frost injury.

While the above instances would indicate that considerable protection might be obtained from running water through a grove during a freeze, it should be stated that, in very many instances, little difference could be seen between the groves that were under water and those that were dry, and in but few cases did the trees under water show any greater vigor in putting out new growth.

In general it seems that one should not rely upon the use of running water to protect the fruit from freezing. In case of emergency no harm will come from running it, and if the temperature does not go too low a slight benefit may result.

*Effect of Spraying Water on Trees.*—In a few places, and on a few trees only, water was sprayed upon trees in order to keep them from freezing. This soon gave the trees a heavy coating of ice, and spraying was stopped so that the ice would not become thick enough to break the limbs. In the few cases which were found where this spraying had been done the practice seemed to have little value.

In the case of seed-beds or small nursery stock that would not be injured by a heavy coating of ice this method of protection might be very effective. In a freeze, such as that under consideration in California, it may be questioned whether the injury that would be caused by such a protective treatment would not in general be as great as the damage resulting from the frost injury. Again, it will never be possible for all groves to have a sufficient supply of water for such protection at the same time, unless a reserve water supply is retained in special reservoirs for each grove.

*Effect of wrapping Trees.*—The difficulty of artificially heating a young grove is greater than with older groves, where the trees are larger and the hot air is more easily retained. The results obtained by wrapping the trunks of young trees are therefore of much practical importance, for if there are ways of protecting young trees which are cheaper than heating the best of these ways should be known.

The principal substances used during the freeze for trunk wrappers were cornstalks, tule, newspapers, and tar paper. Many young trees had protectors about their trunks made of yucca, tar paper, or perforated paraffined paper. These protectors are rectangular pieces, which had been bent around the trunks, forming hollow cylinders, there being an air space between the trunk and the protector. They had been put around the trees during the summer to prevent the sunburning of the bark or its mechanical injury, and were not generally regarded as frost protectors.

Cornstalks afforded a good measure of protection when enough of them were used, and when they were bound firmly enough to keep

them in place and to press them together, so that the free movement of the air between them was prevented. In some cases earth was thrown up around the base of the trees, so as to cover the lower ends of the stalks a foot or so deep. There were young groves of two-year-old trees wrapped in this way that received little injury except to the exposed foliage of the last season's growth, while near-by groves which were carelessly wrapped or which were left unwrapped were badly frozen.

One of the most marked cases of benefit from paper wraps was observed in a four-year-old lemon grove, the trunks of which had been scored during the summer preceding the freeze. All the trunks in the lower half of this orchard were well wrapped with paper, but in the upper half (the grove being on a gentle slope with south exposure) no frost injury was expected, and this precaution of wrapping was not taken. In the latter case severe bark-splitting occurred, it being necessary to renew some trees from sprouts; but in the lower and colder portion of the property there was no such injury beneath the paper wraps. The degree of frost injury to the foliage and tops, however, was in indirect proportion to the elevation. It is very essential in wrapping the trunks to get the wrap well down to the ground, and there is no reason why the entire trunk, instead of only the lower half or three-quarters, cannot be protected if wraps of sufficient length are obtained.

The protectors made of yucca, paraffined paper, tar paper, and the like, open at the top, furnished some protection, but are not equal to good newspaper or cornstalk wrapping. The only serious objection which has been raised to the use of protectors is that, under certain conditions, they favor the development of gum disease.

When young trees are tightly wrapped as a protection against frost, it is important to remove the wrapping before hot weather, as otherwise serious injury may result.

*Protection by Lath-houses, Burlap, or Cloth Coverings.*—Lath-houses, burlap, or canvas coverings afforded good protection to seed-bed stock up to a few degrees of frost.

Lath-houses kept the temperatures within them warmer than the temperatures outside. In one instance the temperature near the middle of a large lath-house was 4 degrees higher than the outside temperature. It was found in this case that it was a degree or so warmer at the center of the house than nearer the sides. Even where there was a covering of lath without any sides, the plants beneath the lath were affected much less than those without any covering. Part of the protection of the lath-house is due, doubtless, to the shading

which it furnishes, causing a more gradual warming of the plants after the frost. At night the lath probably reflects back some of the heat radiated from the ground, and it also shuts in a pocket of warm air.

## PROTECTION BY ARTIFICIAL HEATING

The cold weather of January, 1913, demonstrated to the citrus growers of Southern California that the only successful way thus far devised for fighting cold weather is the use of orchard heaters. To be sure, success was not universal with those who tried to heat their groves, but there were enough successes to show that where the equipment and supplies are adequate and the work well done orchard heating is effective.

So much doubt has existed in the minds of many growers as to whether artificial heating is effective and pays that special observations on selected plots of heated and unheated areas were made by several investigators. A report on some of these observations will be given as a separate article in another part of this bulletin. General statements only will be given here.

*Acreage and General Results.*—In all there were several thousand acres in California that had been equipped with orchard heaters for the winter of 1912–13. In a part of this acreage the equipment was entirely inadequate and allowed only a weak and ineffective effort to be made when the cold weather came. In general, however, those who tried to heat their groves obtained results which satisfied them that it had paid. There were many heated groves where the entire crop was saved and where the trees showed no effects of the cold, while neighboring groves which were unheated lost their crop of fruit and suffered such tree damage that it was two years or more before they began to pay expenses. In some lemon groves where successful heating was done the fruit from the first pick, which was made after the freeze, brought enough to pay the entire cost of heating, including the cost of the equipment, and then paid the grower a good profit besides. In addition to saving the fruit which brought in these returns, the young fruit and bloom of these trees was not frozen and there was no injury to the fruiting wood. Results were not always so satisfactory as this, but failure could always be traced to improper equipment, a shortage of fuel, or a lack of vigilance. Failures were seldom complete, however, and the condition of the trees usually showed benefit from the heating, even when the crop was lost.

*Equipment and Material.*—Most of the heating was done with pots burning oil, many kinds of which were in use in different groves. In

Fig. 7.—On left an orchard coal heater. This is merely an open firebox with grate at bottom. In center, the simplest type of orchard oil heater, being merely an open pail-like structure with holes at top for air draft. on right, a type of torch used in lighting heaters, supplied with asbestos wick and burning distillate or kerosene. Photo by Barrett.

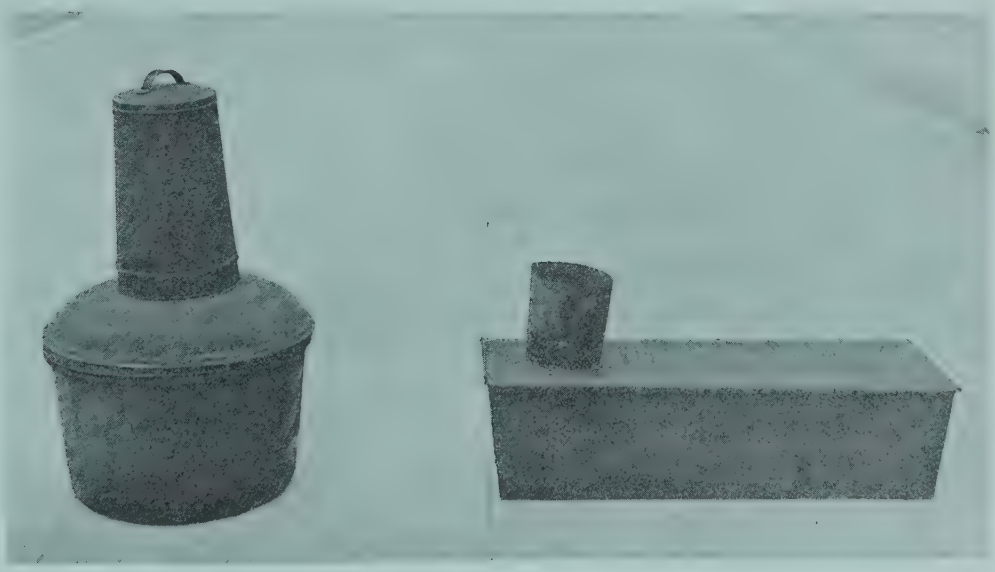


Fig. 8.—On right one of the types of orchard oil heaters very commonly used at the time of the 1913 freeze, having a sliding top and with openings on the side for air draft. On left one of the best orchard heaters that has been perfected since 1913. The smoke stack and drafts are hidden by the cover which is lifted off when heater is lighted. Photo by Barrett.

a few groves baskets and stoves burning coal were used, but in general these did not give as satisfactory results as the oil heaters (fig. 7). Oiled shavings burned in the grove gave little help, and is a method that cannot be depended upon.

The oil pots used varied in capacity from one to four gallons. Some of them were open pots, the shape of flower-pots, some were rectangular with sliding tops, and others were either oblong or round and provided with stacks (fig. 8). The pots which had stacks had the tops covered, but had drafts which could be opened to let in the air. The oil used was a low grade crude oil with asphaltum base, and cost, when put down in the grove, about 3 cents a gallon.

The lighting was commonly done by means of torches that held a gallon of fuel, and had a long spout, inclosing an asbestos wick. Engine distillate, gasoline, or kerosene was used as fuel, and when the torch was tipped some of the burning liquid fell into the pot (fig. 7).

In some cases where new heaters were being used considerable delay was occasioned by the difficulty in lighting the pots, several visits with the torch being necessary. After pots had been burned for some time and had become thoroughly sooted the lighting was accomplished fairly easily. In order to avoid such interruption at a critical period, it seems desirable, either to place a bundle of excelsior in the chimney of each heater, or to light and burn each heater for a half-hour or more before they are required to be lighted during a freeze (fig. 9).

The pots were filled from tank-wagons. Sometimes the oil was drawn from the tank-wagon into buckets and poured into the pots and sometimes a hose was attached to the tank and the oil run directly into the pots. The tank-wagons were filled from storage tanks which were made of steel or of concrete.

These varied in capacity according to the acreage and estimated needs, and many growers found that their estimates had been too low. When twenty or twenty-five cold nights may be expected it is well to have a storage capacity of about 1000 to 1500 gallons per acre in addition to full pots.

As a result of the difficulties experienced in this freeze the tendency hereafter will be to use larger pots of seven to ten gallons capacity and thus avoid the necessity of refilling in the night. The night filling is expensive, because of the higher wage paid the men and the smaller amount of work which they do in the night than in the day, and is responsible for much of the spilling of oil which occurs during the filling of the pots. The oil kills the roots with which it comes in contact, besides rendering the soil unfit for use. Some growers spent

as high as 50 cents a tree in removing this oiled soil from their groves after the freeze.

One conclusion very definitely reached by growers, largely from the results obtained in this freeze, is that in the heating of an orchard it is stoves radiating actual heat that is needed, and not those producing a smudge. The smoke given off by the oil heaters collects to some extent on the fruit and is difficult to remove.

Fig. 9.—Lighting a good recent type of orchard heater by means of a torch containing distillate. The fire being applied to a small amount of excelsior placed in the tube of the down draft. The cover on the right when placed on the heater, extinguishes the fire and excludes rain. Photo by Barrett.

*Methods.*—The groves in which the best work was done were equipped with one pot to the tree. These burned approximately 100 gallons an hour per acre, when they were all going full blast. At these times the temperature of the grove was often from 8 to 12 degrees higher than the temperatures in neighboring unheated groves. Of course it was only during the coldest weather that it was necessary to have all the pots burning at full capacity. Usually only one-fourth or one-half of the pots were lighted, and after these had burned a time they were extinguished and another portion lighted, so that

enough oil was retained in the former to allow for relighting them in case of a sudden drop in temperature.

It was found difficult by many growers to get the right kind of labor and to get the help when needed. The use of larger pots will reduce the amount of night labor needed, and the small ranch of ten acres ought to be handled successfully by two men, if they are vigilant and if their methods are correct.

*Temperature at Which to Fire.*—The experiences of the past have shown that one of the most necessary precautions to take is to begin heating soon enough. There is general agreement that it is easier to hold a temperature than to raise it after it has gone too low. For this reason some of those who have had most experience in heating are planning to begin lighting for lemons at 31 degrees. With oranges a degree or two lower than this may be risked before beginning operations.*

It has also proved of advantage to bank extra pots outside of the grove along the windward side. Not only is this necessary in order to protect the outside rows but it makes it much easier to hold the temperature within the orchard.

*Value of Combined Effort.*—Where large blocks of groves were heated the task of heating was easier than when the heated areas were small and isolated. The effects from the heating on a large acreage were often noticeable at a considerable distance from the groves where the firing was being done. In one section the heating of one hundred acres produced a rise in temperature of from 2 to 3 degrees in groves a mile distant as soon as the smoke reached these groves. The co-operation of growers in the vicinity of Pomona forms a notable example of the benefit of such combined effort. The co-operation can profitably extend to the employment of special observers, maintenance of special danger calls, employment of labor, purchase and storage of supplies, and the like.

*Causes of Failure.*—The principal causes of failure in the heating done in 1913 may be briefly stated as follows:

1. The use of pots which were too small. These burned out quickly and were difficult to refill.
2. Insufficient number of pots per acre.
3. Shortage of fuel.
4. The use of fuel which did not give off enough heat.
5. Allowing temperatures to go too low before lighting.

* See article by J. G. McBeth and J. R. Allison, California Citrograph, Jan., 1919, p. 51.

6. Accumulation in the pots of a residue of asphaltum, which burned with difficulty.

7. Growers relying upon other people's reports of temperatures in other groves rather than keeping track of the temperatures in different parts of their own groves.

8. Discouragement after partial failure. This sometimes proved disastrous.

9. Insufficient amount of labor.

10. Incapable labor.

*Costs of Heating.*—The exact cost of firing in most cases has been difficult to ascertain, and, although considerable data has been gathered on this subject, most of it is too incomplete to make it of value for general conditions. From the data given in connection with a twenty-five acre orchard in the San Fernando Valley we find, after figuring 6 per cent interest on the total equipment and 20 per cent depreciation of the latter, besides cost of fuel and labor, the total cost amounted to 5.09 cents per gallon of oil burned. The pots were lighted on nine different nights. A similar estimate from one ranch in Ventura County, which had one hundred acres of orchard protected with heaters, gives 5.78 cents as total cost per gallon of oil burned. In this case the pots were lighted fourteen different nights. Near Santa Ana the heaters on an eight-acre orange grove were lighted three different nights, thus saving the fruit from considerable frost injury. In this case the cost amounted to 6.13 cents per gallon of oil burned. In the *Pacific Rural Press,* May 24, 1913, figures given by Mr. T. R. Woodbridge of Upland show a total cost of 6.5 cents per gallon of oil consumed.

The cost of the heating operations have varied of course with the amount of heating which was done. In table 2 data are given on the cost of heating in twelve groves selected from different parts of Southern California. These groves were more or less successfully heated. One grower, who kept a very accurate account of all of his expenditures, found that his average cost of heating an acre for one hour was $1.24. His grove was one-half lemons and one-half oranges, and the cost of heating the lemons was 64 per cent of the entire cost. The fruit was saved in the oranges and in half of the lemons, but in the other half of the lemons the equipment was inadequate and the fruit was lost.

In the tables the total number of nights fired is given. On some of these nights the heating was required for only a few hours, while at other times it was needed during the entire night. The interest on the investment has been figured at 7 per cent. The amount charged

TABLE II—DATA ON THE COST OF HEATING CITRUS GROVES IN CALIFORNIA DURING THE WINTER OF 1912-13

| Orchard No. | Acres | Variety | Number of nights fired | Cost of materials | | Cost of labor | | Depreciation | | Total cost | | Cost per acre for one night | Investment in | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Total | Per acre | Total | Per acre | Total | Per acre | Total | Per acre | | Total | Per acre |
| 1 | 12 | Lemons | 23 | $1039.70* | $86.64 | .....* | .....* | $169.00 | $14.08 | $1209.00 | $100.66 | $4.42 | $729.33 | $60.78 |
| 2 | 10 | Lemons | 20 | 379.50 | 37.95 | $475.00 | $47.50 | 115.72 | 11.57 | 970.22 | 97.02 | 4.85 | 713.25 | 71.33 |
| 3 | 20 | Lemons | 16 | 565.00 | 28.25 | 235.00 | 11.75 | 253.37 | 12.67 | 1053.37 | 52.67 | 3.30 | 691.00 | 34.55 |
| 4 | 15 | Lemons | 7 | 451.50 | 30.10 | 122.00 | 8.13 | 217.92 | 14.53 | 791.42 | 52.76 | 7.54 | 784.50 | 52.30 |
| 5 | 14 | Lemons | 16 | 437.00 | 31.21 | 201.50 | 14.40 | 147.12 | 10.51 | 785.62 | 56.11 | 3.51 | 573.25 | 40.95 |
| 6 | 15 | Oranges and Lemons | 21 | 528.25 | 35.22 | 372.13 | 24.81 | 167.00 | 11.13 | 1067.38 | 71.16 | 3.40 | 734.00 | 48.93 |
| 7 | 7 | Oranges | 22 | 181.25 | 25.89 | 132.00 | 18.86 | 65.00 | 9.29 | 379.25 | 54.18 | 2.46 | 216.30 | 30.90 |
| 8 | 22 | Oranges | 5 | 211.00 | 9.59 | 320.60 | 14.57 | 273.51 | 12.43 | 804.51 | 36.50 | 7.30 | 987.75 | 44.90 |
| 9 | 7 | Oranges | 19 | 189.50 | 27.07 | 93.75 | 13.39 | 66.77 | 9.54 | 350.02 | 50.00 | 2.63 | 245.00 | 35.00 |
| 10 | 10 | Oranges | 9 | 211.50 | 21.15 | 64.00 | 6.40 | 106.35 | 10.64 | 381.85 | 38.19 | 4.24 | 401.10 | 40.11 |
| 11 | 20 | Oranges | 5 | 435.60 | 21.78 | 232.00 | 11.60 | 334.63 | 16.73 | 1002.23 | 50.11 | 10.02 | 1282.38 | 64.12 |
| 12 | 20 | Oranges and Lemons | 17 | 766.56 | 38.33 | 499.05 | 24.95 | 398.90 | 19.95 | 1664.51 | 83.23 | 4.90 | 1445.17 | 72.27 |

* Included with materials.

off to depreciation has varied according to the equipment and the usage that it received. The depreciation on the oil heaters has usually been as high as 25 per cent and that on the other equipment probably about 10 per cent.

The cost in the groves where the best work was done ranged from 5½ to 6½ cents per gallon of oil consumed; or, figured on the acre basis, from $50 to $100 an acre was spent in these groves. With increased experience and improved equipment, it ought to be possible in the future to lower these costs. At present the items of labor and of depreciation contribute too large a percentage to the total cost. The equipment of the future will probably last longer and require less attention during its operation.*

## FACTORS INFLUENCING RESISTANCE OF TREES TO COLD INJURY

It has already been noted that there was a marked difference in the resistance that different citrus trees showed toward the cold weather. Trees side by side were often very differently affected. It was evident that these differences were not always due to differences in temperature, and a search was made to discover why certain trees should have withstood the cold so much better than others.

*Dormancy of Trees.*—Trees that were dormant and inactive were able to stand much more than those which were growing and where the parts of the plant were actively functioning. Orchardists recognize this fact by their expression that trees in a "sappy" condition are more easily damaged than trees which are more "mature."

The treatments that stimulate a tree to growth or to activity, therefore, should be omitted, if possible, when cold weather is to be expected. This applies particularly to young trees. Some growers feel that with lemons, at least, it is more profitable to keep the trees growing through the cold weather and protect them from damage by heating.

Some of the things which influence the dormancy of citrus trees, as recorded by the freeze, are dryness and the time of irrigation, pruning, and, in young trees, the time of planting.

*Time of Planting.*—Young trees which were planted so late in the fall that they had not started to grow at the time of the freeze were much hardier than trees similarly located that had been planted in the summer or in the spring and were growing. In one young grove, that was set in the spring of 1912, most of the growing trees were

* The California Cultivator, Los Angeles, June 26, 1913, gives some excellent articles on the protection of citrus groves against cold.

The Pacific Rural Press, San Francisco, May 24, 1913, has an excellent statement on cost of heating.

The Monthly Bulletin, State Commission of Horticulture, vol. 3, no. 1, has an article giving costs of heating a large acreage.

killed half way to the ground, while trees that had not started were uninjured. In another grove of two-year-old trees some resets, that had been planted in the fall, mere green sticks, were uninjured, while the two-year-old trees all about them were killed to the ground.

*Dryness.*—It was very common to find trees which on account of being dry were less injured than those which had received more water. If the trees had become so dry during the summer, however, that they had shown the effects of drought, they were often severely injured by freezing. In a grove of young trees three or four years old, that had received scant irrigation during the summer, the trees farthest from the head ditch had become, before the freeze, yellow-leafed and looked as if they were dying. These trees were frozen to the ground, but nevertheless most of the trees of this grove were less injured than those in near-by groves that had received more water. Of course it would not be desirable to keep a grove dry and dormant all summer in order that it might live through the winter. These cases are referred to merely to show that dormancy in some cases was induced by dryness, and that it is best not to give a young grove too much water in the fall of the year.

*Irrigation.*—It was found that even when trees had been well supplied with water during the summer the interval that had elapsed between the freeze and the time of the previous irrigation frequently influenced their hardiness. A number of places were found where all of the factors were the same except the time of irrigation and where there were marked differences in the injury which the differently irrigated portions had sustained. In these cases the trees that had been irrigated about two weeks before the freeze were damaged more than trees which were about six weeks from irrigation. Even when it is likely that all of the trees had their conducting vessels well supplied with moisture there was sometimes a difference in condition among these trees corresponding to the differences in the intervals that had elapsed since the previous irrigation. To illustrate, in one grove water was running over the entire grove at the time of the freeze. Most of the grove had not been irrigated before for about six weeks, but a few rows at one side of the grove had been given an extra run of water about two weeks before the freeze. These rows were much more damaged than the rest of the grove.

While the number of conflicting cases observed make it difficult to deduce any general rules, it seems safe to conclude that trees which were suffering from lack of water and trees that contained the maximum quantity of water were more severely injured than trees that contained a medium amount of water.

*Pruning.*—It has been the practice of many lemon growers to prune in the fall of the year. Groves were found where trees that had been pruned at this time were much more seriously injured than unpruned trees which were under otherwise similar conditions. The most severe damage was to those trees that had started a vigorous growth as a result of the pruning. In one grove of young trees, which had been stimulated into growth by pruning, the bark of the trunks and limbs was badly split. Some adjacent trees of the same age and similarly located, which had not been pruned, were injured but little. The pruning was done the last of September, so that in this case there had been a three months' interval between the pruning and the freeze.

Where the cutting had been done so late that no new growth had started there was, as a rule, no noticeable difference in resistance between the pruned trees and those which had not been pruned. In one young grove, however, a very marked difference was to be seen between some trees which were unpruned and some adjacent rows where the pruning had been discontinued the night before the freeze. The grove consisted of four-year-old Eureka lemon trees and the cutting had been moderate. There was a very marked difference in condition between the section which had been pruned and that which had not been pruned. This difference was not so decided immediately after the freeze as it was when the trees began to grow. At this time the unpruned trees showed much more vigor than the other trees. The pruning of the grove was finished in the spring and all of the trees had been made the same size, so that there was no difference in that respect. Any one in walking through the grove could easily tell to a row where the pruning had been done before the freeze.

A few instances of late pruning were found which resulted in a greater loss of fruit than in trees not pruned. This, of course, is to be expected, for the abundant top growth affords considerable protection to the fruit.

*Unhealthy Trees.*—Sickly trees were invariably more severly injured than vigorous, healthy trees. This was very noticeable in the case of trees suffering from such diseases as gummosis and scaly bark. Trees that had been badly infested with insect pests were damaged more than trees which were in good health and free from pests. Branches that had been attacked with red spider were completely killed in many trees which suffered only partial defoliation of the other branches.

Sometimes healthy trees had been given some treatment before the freeze that weakened them and augmented the frost damage. For example, young trees which had been scored along the trunks on one

or two sides, with the idea that by thus cutting out a narrow strip of bark growth could be hastened, were much oftener found with split and loosened bark after the freeze than trees where the bark had been left intact. The demonstrations of this point were so general that the method of scoring young trees will probably not be practiced in the future.

Fig. 10.—Two-year-old Eureka lemon on which bark had been slit longitudinally (scored) with knife before the freeze and which the freeze further seriously injured though the foliage of the tree remained uninjured. Scoring the bark in this way does no good and may cause serious injury. Photo by Tylor, July 5, 1913.

Some ranchers had practiced rubbing neatsfoot oil on the bark of trees which were affected with gum disease. Occasionally a man was found who had put this oil on the bark of healthy trees, reasoning that if neatsfoot oil was good for trees suffering with gum disease, which it is not, it should be a good preventive measure. In some of these places, where large bearing lemon trees that had been in good health but had had the trunks painted with neatsfoot oil as a preventive against gummosis, the oiled trunks had all of the bark killed, while trunks which had not been oiled had their bark unharmed.

Although the observations as to greater frost injury to sick trees were in most cases from a few isolated trees in individual orchards, where the majority of trees were healthy, the same general results have been noted between entire groves in the same section, and under practically the same condition as to elevation and temperature. Although immediately following the freeze there was little difference in appearance between groves in various states of vigor, the greater recuperative powers of the healthy, well cared for, clean orchards than of dirty, sickly, poorly cared for groves has been very marked.

*Influence of Trunk-Section of Top-Worked Trees.*—A very interesting difference which was brought out by the freeze was that of the resistance offered by trees which had the same kind of tops but different kind of trunks. Of course most of the citrus trees have the top and the trunk the same, as they are budded low. But there are many groves in which the trunk of the tree is lemon and the top orange, the trees having been worked over from lemons to oranges at

a time when lemons were not paying. There are also some places where trees with lemon tops have orange trunks.

Several places were found where young trees with lemon tops and orange trunks were set among lemon trees of the same age which had lemon trunks. In one of these places the trees were all of the same age, having been set about one year. Most of the trees had lemon trunks, but there were two rows of trees in the middle of the grove that had Valencia trunks with lemon tops. The trees of the grove were uniform in size, and previous to the freeze there was nothing to draw one's attention to the fact that some of the trees in this young lemon grove had orange trunks. After the freeze, however, any one passing this grove would have noticed that two rows in it differed in some important respect from the rest of the trees. For the trees with orange trunks bore branches covered with green leaves, live lemon branches and lemon leaves, but the other trees in the grove were killed nearly or quite to the ground. Four other places were found where young lemon trees with orange trunks were adjacent to young lemon trees on their own trunks, and in all of these cases the trees with the orange trunks proved much hardier. It might be thought from this that the superior hardiness of the trees with orange trunks is due to the well known greater resistance to freezing which orange wood possesses. It is rather hard to see on this basis, however, why the lemon tops of the trees with the orange trunks should have been so slightly injured. The superior resistance of the trees was not confined to the trunks, for their lemon tops were hardier than the tops of the trees with lemon trunks. It is clear that the trunks of these trees had influenced the tops and had increased their hardiness. This probably means that in some way the trunks of the trees modified the dormancy of the tops.

Not many bearing groves have been worked over from oranges to lemons, so that it has not been possible to find many comparisons between such groves and bearing lemon trees on their own trunks. Some bearing lemon trees with orange trunks were found, and also some bearing lemons which had tangerine trunks, but these trees did not seem to be strikingly hardier than ordinary lemon trees.

It was much easier to find bearing orange groves where the trees in parts of the grove had lemon trunks. Such groves are rather common in southern California because about ten years ago there was such a depression in the lemon market that many growers budded their lemon trees over to oranges.

In some places these orange trees with lemon trunks were injured much more than adjacent orange trees on their own trunks. One

grove of navel oranges was found where every other tree in the row had a lemon trunk. In parts of this grove the trees with the lemon trunks had lost two or three times as many leaves as the trees with the orange trunks. Numerous other cases were found where orange trees with lemon trunks were injured more than similarly situated trees with orange trunks, but the reverse of this sometimes occurred, so that no positive rule can be stated. It is, however, pretty clearly evident that it is, in general, poor policy to top work lemons to oranges.

*Influence of Roots or Stocks.*—It has been claimed that the root-stock on which the tree is budded may affect the resistance of the top. The stocks that have been most used in California are the sweet orange and the sour orange. In general, no difference in the resistance of the trees on these two stocks could be found.

In one rather large nursery, containing both sweet and sour seedlings, all the trees were killed to the ground in January, but on June 12, 1913, a count of several hundred trees of each variety showed that 71.3 per cent of the sweet and 71.2 per cent of the sour trees were recovering, and new sprouts several inches long were growing from the young trunks near the surface of the ground.

*Comparative Resistance of Sweet and Sour Stock*

| | Number trees counted | Number trees producing new sprouts | Per cent trees recovering from freeze |
|---|---|---|---|
| Sweet Orange | 882 | 629 | 71.3 |
| Sour Orange | 795 | 566 | 71.2 |

Pomelo stock has been used by many growers, but no cases were found where the trees on this stock were noticeably different from those on other stocks.

In one young lemon grove the trees on trifoliate orange roots were hardier than the trees on sour orange roots. At least one case was observed in California where navels on trifoliate stock appeared to be distinctly less injured than navels on sweet stock planted at the same time and in the same grove, and having the same treatment. In general, it may apparently be concluded that the trifoliate stock has a tendency to render orange budded on it rather more hardy, but that the difference is slight.

In some cases there is apparently a definite influence of the tops upon the stocks. In one case, in the spring of 1912, a nursery of sour seedlings was budded to Eureka lemons. Many of these buds did not take, so that during the freeze of January, 1913, there were in this nursery, at the same elevation and under the same conditions,

yearling lemon tops on sour stock (buds had been inserted several inches above the ground) alongside of sour seedlings. While a slight injury to the foliage was the only harm experienced by the latter, the lemon tops were killed, and the frozen wood extended three to four inches down on the sour stock. Similar conditions were found on pomelo stock, while the pomelo seedlings were scarcely touched.

*Individuality of Trees.*—One of the most pronounced features of the freeze was the greater resistance of some individual trees to frost injury than of other trees, of the same age and kind and growing under the same conditions. This perhaps was more apparent in young orchards than in old ones, and many instances have been seen in which the majority of trees in a young lemon grove have been killed to the bud, while here and there scattered irregularly through the grove were individual trees retaining a certain proportion of green foliage. The same individuality of trees occurs in old groves, but is not always so well defined.

In no case was it possible to determine whether the escape of these trees from injury was due to accidental conditions, rendering such trees more dormant and thus more resistant, or whether due to inherent frost-resistant qualities.

## TREATMENT OF FROZEN TREES

Soon after the freeze it became apparent that the citrus groves had been very seriously injured and growers were confronted with many important problems connected with their rejuvenation. No experience was available to serve as a guide, and thus many different methods were tested that appeared to give promise of value. The trees given these different treatments were watched, and it has been possible to reach definite conclusions regarding the value of most of the practices which followed the freeze.

*Binding Loose Bark.*—In many places where loose bark was bound back to the tree again apparently nothing was gained, for the loosened bark died. Many growers, however, reported that they had trees the bark of which was loose immediately after the freeze but which later reunited with the wood.

Considerable uncertainty exists regarding most of these reports, but it is probable that some of them are true, inasmuch as there were many examples where the bark had split and separated from the tree without being killed. This bark not only remained alive but developed a layer of wood on its inner surface, and a new bark was developed next to the wood of the tree.

Some trees were found which clearly showed that such an occurrence actually took place. The bark on the north side of a three-year-old lemon tree had been longitudinally split and had separated from the wood for an inch and a half or so on each side of the split. At one place it had been tied down to the tree again by a piece of twine, which brought the wood and bark together at this place only. Both above and below the twine the bark had remained separated from the tree. The bark was not killed, and where it had been tied it had reunited firmly with the tree.

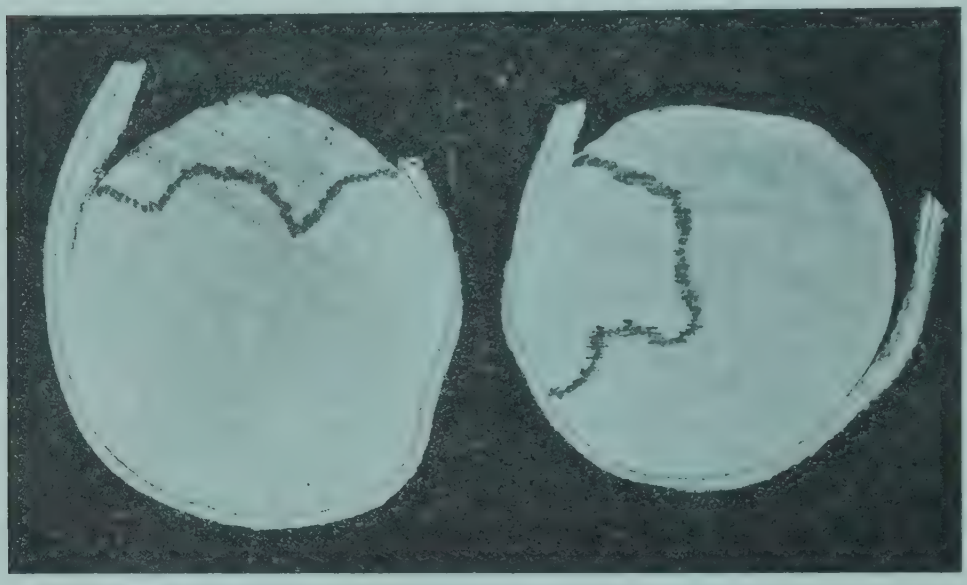


Fig. 11.—Cross section of young lemon trunks on which bark was split by freezing, showing the injury to the wood which is dead back to the inked lines. New wood can be seen forming on the loose ends of the bark which was not killed.

In many cases where split trees were wrapped the process was so thoroughly done that the moisture was held in and molding favored. The best instances of recovery from wrapping were those where cord, like binding twine, or narrow strips of cloth were wrapped around the tree spirally, leaving the greater portion of the bark uncovered and allowing the free access of the air, but holding the loose bark firmly against the wood. Such wrapping to have any effect must be done promptly after a freeze, while the injured surfaces of bark and wood are fresh, otherwise the wrapping naturally could have no beneficial effect. Where bark is split and loosened it is likely to bend outward as it dries and exert a force that will have a tendency to extend the injured area. Binding with cord as indicated will prevent such extension of the injury and favor the bark healing on, while

it is not too severely injured. In many cases where no beneficial results were observed from wrapping the treatment was applied too late, or the injury was so severe that no treatment could be effective in saving the injured parts (fig. 12).

Where trees are treated in this way following a freeze they should be given no other treatment, unless the trunks are whitewashed to protect them from sunburning. No further treatment than the wrapping is necessary for several months, or until the new growth is well under way and until bark that was killed has dried out and clearly shows the extent of the damage. As soon as this time arrives, the wrappings should be removed, the dead bark thoroughly cut away, and the injured patches thoroughly cleaned. After this cleaning, probably the best treatment is to first paint the injured area with Bordeaux paste and some weeks later with asphalt dissolved in benzine. The use of Bordeaux paste as a first treatment seems to be very desirable, as it seems necessary to use some sterilizing solution to prevent the development of fungi. Following this treatment with a coating of asphalt paint renders the wound impervious to water and gives a permanent finish to the treatment.

Fig. 12.—Four-year-old Eureka lemon, on which the split bark was covered with grafting wax and wrapped with twine. Treatment apparently did no good because of grafting wax. Loosened bark promptly wrapped with twine without other treatment frequently healed on. Photo by Tylor.

*Waxing and Painting Split Bark.*—The covering of the splits in the bark with grafting wax was a very common practice. Some growers used white lead instead of wax. Sometimes the bark was wrapped after the waxing, and sometimes the waxing was the only treatment given. Where there was a chance to compare waxed trees with those that had not been treated, there was nothing to show that the waxing had done good. It was practically impossible to get the wax under the loose bark, and so the wax simply sealed up moist

chambers which offered most favorable conditions for the growth of fungi. Even where the wax was put on before there was much loosening of the bark, it did little good because the later loosening and curling of the bark cracked it (fig. 12).

White lead, applied by painting the cracks soon after the freeze, proved no more valuable than wax, and no places were found where trees were in any way benefited by having the trunks wrapped in

Fig. 13.—Badly injured Eureka lemon tree, unpruned, five and one-half months after freeze, showing the extent of damage and the new growth that has developed. Trees at the stage shown in this illustration can be pruned to advantage, all of the dead wood being removed at one time. Photo June 24, 1913, by Tylor. (This tree was immediatley beside that shown in fig. 14.)

cow dung. Some cases have been reported, however, where gummosis was started by this treatment.

*Pruning Injured Trees.*—One of the most important operations necessitated by the freeze was pruning. It was maintained by some that prompt pruning was very necessary in order to prevent a further dying back of the frozen wood. This dying back would be caused, it was claimed, by a backward passage of sour sap. However, difficulty was experienced in telling soon after the freeze where the uninjured portions of wood began. So when it was advised on the special Frost

Train, run by the College of Agriculture of the University that it would be better to wait, whenever the damage had been at all severe, until the extent of the damage became clearly defined, the majority of the growers adopted this policy.

The effect of early and late pruning was easily observed and was tested out by many growers. The following two instances may be cited as definite experiments. In one orchard of old lemon trees a

Fig. 14.—Badly injured Eureka lemon tree, pruned February 1, 1913, and photographed four and one-half months later, showing the dieing back of large limbs after the first pruning. Such early pruned trees as this made no better growth than unpruned trees and required a second pruning. Photo by Tylor June 24, 1913 (compare fig. 13.)

certain portion of the trees were cut back in February, and all wood at that time thought to be dead was cut out. A check row, however, was left, which was not pruned until summer. The cuts made during February were in most places on wood that ultimately died. In this case there was no apparent difference in amount of new growth produced on the trees under the different treatments, but in the case of the early pruning, a second cutting was necessary in order to completely remove all the dead, frozen branches (figs. 13 and 14).

In an experiment, carried out by the Citrus Experiment Station

through the kindness of the Arlington Heights Fruit Company, seven-year-old lemon trees that were rather severely injured were pruned in several different ways. About ten trees were treated by each method, the pruning being done about the middle of March, 1913, thus somewhat over two months after the freeze. Row 1 was left entirely unpruned. In row 2 the trees were pruned moderately, limbs being removed as far back as they were thought to be injured. In row 3 without reference to injury, the trees were cut back to the principal branches, thus being very severely pruned. In row 4 the trees were cut off below the crown, leaving thus only the trunks.

No further pruning was given until May, 1914. At this time it was clearly evident that row 1, unpruned, and row 2, lightly pruned, had developed the largest tops and the most fruit, there being no fruit on the other rows. The dead branches on row 1 had up to this time caused no injury and could be easily distinguished and removed. The growth on these trees after pruning seemed to be, as a whole, better, more vigorous, and more fruitful than on any other row, though scarcely any better than row 2. Row 2, however, required a second severe pruning, the treatment thus being much more expensive than the one pruning given row 1. The pruning in rows 3 and 4 had clearly been too severe to give the best results.

The treatment of limbs on which large patches of bark were killed is very perplexing. Where a limb was partially girdled, it was a question how wide a strip of living bark it should have in order to give satisfactory growth. No positive directions can be given regarding such variable cases, as judgment must be used in every case. It is thought, in general, that where a limb is more than half girdled, it would be better to remove it and allow a strong new branch to take its place.

It must be remembered that in pruning frozen trees, it is highly important to treat the large cut surfaces with a fungicide, such as Bordeaux paste or Bordeaux mixture, followed with asphalt paint.

The results obtained in these experiments correspond entirely with the experience of growers all over the state, and demonstrated conclusively that early pruning after a freeze is unnecessary, does no good, and increases the expense, as a second pruning is necessitated. It may do damage to some extent, by causing sunburning. Far the best method is to delay the pruning for from five to six months or longer, until the trees have had time to throw out new growth and plainly delimit the dead portion. All necessary pruning can then be done at one time. The early pruning of lightly frozen trees, in lemons especially, is likely to remove uninjured fruit wood and lessen the following crop.

The early pruned nursery stock was found to be slower in starting growth than unpruned stock, a delay of as much as three weeks being observed in some cases.

Many growers did not attempt to remove the small frozen twigs in lightly injured trees. Leaving this dead brush in the tree was found to increase the amount of fruit spotting, and decay the next year.

*Removing Frozen Fruit.*—As soon as it was learned that the fruit had been frozen, some growers had it promptly removed. This cost for oranges from five to ten cents per tree on the average, while some lemon growers had to pay as much as twenty cents per tree.

Experience demonstrated that there is no need of haste in removing frozen fruit, unless it is to be used for making by-products. Some of the frozen fruit will drop of its own accord and if wood injury necessitates pruning much of the old fruit will be removed by this operation. What remains can be pulled off later at any convenient period. There was no evidence obtained indicating that the succeeding crop was injured by this frozen fruit remaining on the tree, other than the injury that may result from the spreading of fungus spores from the old fruit, thereby increasing spotting in the next crop.

*Whitewashing Exposed Trunks.*—Where trees were defoliated, many growers felt that the bark should be protected in some way from the burning action of the sun. The most feasible way to do this was to whitewash the trees, and this was done in many cases. Where the whitewash was put on before any new growth had started, the appearance of the new growth was delayed about three weeks. When the application was not made until after the growth had started, the tender leaves were sometimes injured. The whitewash was always cooled before using it, but there were many examples where after it had cooled over night, it injured tender growth. Where it was allowed to stand a week before being put on, it had no injurious effects.

In case there are but a few trees to be treated, the whitewashing of bare trunks and limbs can be done with a brush, but on the larger ranches, the most economical system is to make a thin wash that will go through a spray nozzle and apply it by means of a power spray pump. (See formula below.*)

*The Renewal of Badly-Injured Young Trees.*—Young lemon and orange trees suffered various degrees of injury, but were much more generally and severely injured than older trees. Severe cases of sun-

* Formula for California Whitewash: Take 30 pounds of quick lime, 4 pounds of tallow, 5 pounds of salt, and mix together, slake slowly and blend. Dilute with enough water to make mixture flow well.

burning frequently resulted on the south side of defoliated young lemon trees in particular and the whitewashing of the trunks of such trees soon after a freeze is important.

Aside from whitewashing, there seems to be but one fixed rule, and that is to let the trees alone until the new growth is well under way, and the demarcation between dead and living wood has become plainly apparent.

Fig. 15.—The development of a new tree from a sprout springing from base of trunk above the bud, the old trunk being retained for a time as a stake for the new tree. Photo by Tylor, September 6, 1913.

The method of renewal of young trees depends entirely on the degree of injury. If the trees have lost only a portion of their heads, a new head may be shaped after the growth is well under way. With trees that lost their entire crowns but retained sound trunks, as happened in many cases especially where they had been protected by a wrap during the freeze, it proved to be thoroughly practical to train three or four sprouts, properly located and spaced near the top of the trunk, to form the new head.

If the trunk is killed too far down to produce a good-shaped head, but is still living above the bud, the best method of renewal is to select a strong sprout that springs out above the bud and train it into a new tree, retaining the old trunk as a supporting stake until the sprout becomes strong enough to need no support. Remove all other sprouts and throw the full strength of the tree into this one sprout. Many young sprouts that did not even start growing until the middle or latter part of March, trained in this manner and headed before the August growth, in seven or eight months made splendid young trees, better than new trees planted in the spring. Whatever system of renewing young trees is followed, it is important to start below all large areas of dead wood. There is too much at stake to grow a new tree for several years on a rotten foundation. If the main crotch has been badly frozen and the dead bark and wood extends downward from this injury, sacrifice the top and start the new head from healthy tissue (fig. 15).

*Grafting or Budding Badly-Injured Trees.*—Where trees were frozen down to the bud, one of three things was done: the trees were uprooted and thrown away; or they were allowed to send out new shoots, one of which was budded; or they were cut off and grafted. Grafting was successful in some places, and failed in others. The two methods used were cleft-grafting and crown-grafting. Where the tree was one or two inches in diameter, it was sawed off down to good live wood, was split, and then two wedge-shaped scions were put in by the cleft-graft method, one on each side, so that the cambium of the scion came next to the cambium of the stock. Where the trees were so large that they could not easily be split in this way, a stick of bud-wood with one end cut diagonally was placed between the bark and the wood, with the cut surface next to the wood. The failures were caused mainly by the drying out of the scions before they had united with the stocks, or by the dying back of the stock below the place where the scion was inserted. Grafting, in general, proved unsatisfactory.

The most successful method pursued was to train up a vigorous sprout from the stock which was budded in the summer as soon as it had reached sufficient size.

*Irrigation to Aid Recovery of Frozen Fruit.*—It was thought by some people that fruit which had been partly frozen would recover if the conditions were favorable, and that frequent irrigation would assist in this recovery. Irrigation was given a fair trial in several cases with Valencias and navels, but the fruit was not benefited, showing no improvement over adjacent groves which were not irrigated. In fact, no places were found where there was any recovery of fruit after February 1 which was of any commercial importance. Some frozen lemons were examined in which it looked as if new pulp cells had formed next to the skin, but this was not general enough nor extensive enough to need consideration commercially. Instead of any recovery taking place in frozen fruit, there was a steady deterioration the older it grew.

*Stimulating Growth in Frozen Trees by Fertilization.*—Many growers following the 1913 freeze gave their trees extra applications of nitrate of soda and other quick-acting fertilizers, thinking thereby to stimulate more rapid growth and cause the flowers to set more fruit. Little or no benefit was derived from such extra applications, though no harm was done, as has sometimes followed in Florida. The omitting of all fertilization, however, was very clearly a mistake, unless the freezing had been so severe as to kill all or the greater portion of the tops, or in cases where the grove had been highly fertilized a short time preceding the freeze.

*Treatment of Wounds on Frozen Trees.*—Reference has been made in various places to the necessity of properly treating wounds on frozen trees, both in the case of areas injured by the freeze and of wounds caused in pruning. In several sections of the state, wood rots were spread in the pruning and apparently caused considerable damage. In almost all cases some material was used by growers to cover cut surfaces, such as grafting-wax applied warm, liquid grafting-wax, white lead, or some sort of paint. It was found by Dr. Barrett and Professor Fawcett that these did not stop the infection with the wood rots spread by pruning. These fungi developed under the wax or paint. In the treatment of the wounds, in case of trunk injuries and comparatively large cut surfaces in pruning (limbs one-half inch or more in diameter), the best treatment that can now be suggested is painting these, when freshly cut, with Bordeaux mixture or Bordeaux paste* and a few days later following this by painting the cut surfaces with asphaltum dissolved in benzine, which gives a hard smooth finish that will last for a long period. Asphalt paint dissolved in benzine (use no turpentine) can be purchased at paint stores.

## AFTER EFFECTS OF THE FREEZE

For six weeks or so after the freeze, there were no changes in the appearance of the groves, which could be looked upon by the rancher as encouraging signs. During this time the injury done to the bark became more apparent day by day: green bark became dull in color and then dark brown; cracks opened wider; and the leaves kept falling except in some places where the freezing had been most severe. In these places the dead leaves did not drop but remained hanging as if they were frozen on.

*Appearance of New Growth.*—Toward the latter part of February, however, the buds began to start, and new growth appeared in abundance. This growth was not confined to parts of the tree which showed no injury. Of course, there was much wood upon which no new growth appeared, but new shoots sprang out from many branches and trunks, which were so badly split that the owners were greatly

* Bordeaux paste formula: Dissolve 1 pound of bluestone (copper sulfate) in 1 gallon of water in a wooden or earthen vessel. This can best be done by hanging it in a sack in the top of the water. Slake two pounds of quicklime in about one-half gallon of water. Some variation from these proportions may be made without greatly changing the value of the paste. Stir together when cool, making a light blue mixture about the consistency of whitewash. If the mixture turns to some other color before being applied, it is an indication that something is wrong. Mix up fresh each day or two, as the mixed paste tends to deteriorate with age. It may be applied with a large brush as whitewash.

surprised to see them putting out such an abundant and vigorous growth.

*Dying of New Growth.*—After this growth had become a few inches long, much of it began to droop and die. A few weeks later many young trees, which had started out with promise, were entirely dead, and other trees kept weakening and dying throughout the summer. Sometimes some of the new growth would droop and die because of overcrowding. Frequently when two or three shoots sprang from the same place, all would continue to grow until six to ten inches long, and then one or two of these would droop, become loose, and fall out, leaving one strong sprout. Where there were these fatal effects of overcrowding, the trees were doubtless in a weakened condition. Orange trees that were merely defoliated sent out a strong and abundant growth along the trunk and the main limbs of the trees. This growth had large leaves of good color and bore strong vigorous flowers. The leaves that came out near the surface of these trees were generally small and often variegated. This variegated color was plentiful in groves which had previously been free from "mottled leaf."

Where the bark was split, the loosened bark usually curled and died, leaving an elliptical patch of uncovered dead wood. The sound bark surrounding this area began to grow in from all sides and cover this bare wood the same as in the healing of any wound.

After two or three months, trees which had been exposed to the lowest temperatures began to show dead patches of bark on some of the big limbs. These patches were not conspicuous, but could be located by scraping off the outer surface of the bark. The scraping revealed the brown areas, surrounded by bark, which was green and alive. It was rare to find bearing trees ten years old or older, even in the districts which suffered most, where the trunks of the trees showed much injury.

*Blooming and Fruiting of Injured Trees.*—Slightly defoliated orange trees, even though the crop had been a total loss, in many cases set a larger crop than normal. Orange trees that had been entirely defoliated in January produced bloom in March and April, a large portion of which was small and dropped. During this time strong, vigorous growth was developing on the large limbs within the tree and fruit developed on this newly formed growth. The crop of these trees, which had been entirely defoliated and badly injured in January, was found, to the astonishment of many, to equal in many cases 40 to 60 per cent of normal.

Lemon trees that had suffered but slight frost injury to the fruit,

in many cases set a heavy new crop. In many instances it was found that lemon trees, entirely defoliated in January, produced considerable bloom in the spring, but a large proportion of this dropped. The amount of fruit on the lemon trees in the fall was proportional to the amount of fruit-wood not killed during January. Where the trees were killed back to the framework or to branches one or two inches in diameter there was no bloom for twelve months after the freeze, although much new growth was produced.

The devastation wrought by the freeze was so severe that growers feared that no crop would be produced the next year. In this they were fortunately mistaken. In the case of orange trees where the injury was not too severe, the check to the vegetative development apparently acted like girdling and stimulated a heavy bloom and set of fruit. It is interesting to note that similar conditions followed the 1886 freeze in Florida, which was about of equal severity with the 1913 freeze in California. The Florida crop of oranges the year following this freeze was larger than the crop of the year preceding the freeze (see table 3).

TABLE 3.—FLORIDA CITRUS FRUIT CROP FROM 1884–85 TO 1888-89

| Season | Oranges, boxes |
|---|---|
| 1884–85 | 600,000 |
| 1885–86 | 900,000 |
| 1886–87 (freeze Jan. 12, 1886) | 1,260,000 |
| 1887–88 | 1,450,000 |
| 1888–89 | 1,950,000 |

Nearly the same conditions followed the California freeze, as will be seen from a comparison of the shipments of oranges and lemons for the years preceding and following the crop year of 1912–13 (see table 4).

TABLE 4.—SHIPMENTS OF CITRUS FRUIT FROM CALIFORNIA, 1909-10 TO 1917–18

| | Carloads | | | Boxes (approximate) | | |
|---|---|---|---|---|---|---|
| | Orange | Lemon | Total | Orange | Lemon | Total |
| 1909–10 | ---------- | -------- | ---------- | 11,300,246 | 1,516,021 | 12,876,267 |
| 1910–11 | 39,360 | 6,721 | 46,081 | 15,575,631 | 2,256,066 | 17,831,697 |
| 1911–12 | 33,671 | 6,104 | 39,775 | 13,319,002 | 2,241,990 | 15,560,992 |
| 1912–13 | 17,432 | 2,806 | 20,238 | 6,908,084 | 1,117,940 | 8,026,024 |
| 1913–14 | 42,706 | 2,848 | 45,554 | 16,957,335 | 1,202,964 | 18,160,299 |
| 1914–15 | 40,986 | 6,658 | 47,644 | 16,336,433 | 2,639,296 | 18,975,729 |
| 1915–16 | 37,336 | 7,319 | 44,655 | 15,169,559 | 2,945,589 | 18,115,148 |
| 1916–17 | 45,723 | 8,107 | 53,830 | 19,702,443 | 3,312,042 | 23,014,485 |
| 1917–18 | 19,506 | 5,823 | 25,329 | 8,940,820 | 2,452,481 | 11,393,301 |

(Cars of varying capacity.)

Several factors contributed to make the crop of 1913–14 appear larger than it really was in comparison with preceding crops. The crop of 1911–12 was reduced by the loss of considerable fruit through the Christmas freeze of 1911. The crop of 1912–13 was largely destroyed by the great freeze. There had, therefore, been two years without a normal crop. Meanwhile, very extensive areas of young plantings had reached bearing age, and served to greatly increase the crop of 1913–14. There were many acres of old, bearing trees and trees of all ages, where the crop was very greatly reduced by the freeze. The average yields per acre, therefore, were much smaller than in many preceding years, although the total crop was fairly large.

The lemon trees were much more severely injured, the fruit-bearing wood being destroyed in many sections. The crop of the year following the freeze, 1913–14, was thus comparatively small, as will be seen by an examination of table 4, giving the yields for the last nine years.

*Planting Frosted Nursery Trees.*—During the summer following the freeze, some cases were reported of loss due to the planting of nursery trees that were more or less injured by the freeze in January but that had recovered sufficiently to be sold for planting several months later.

The reason for this is probably due to the fact that the injured tree, in order to produce a new top, or a new top and portion of the trunk, must draw upon its reserve food material stored in roots and trunk for this new tissue, and that the trees had not had sufficient time before the second shock of transplanting to replenish this reduced reserve food, which is necessary in order that the plant may recuperate when set in the orchard.

*Thawing and Recovery of Frozen Fruit.*—It has long been known that if frozen tissue is suddenly heated or thawed rapidly, it is severely injured, but if gradually thawed, it often escapes injury. There seems but little doubt that, had the freeze of 1918 been followed immediately by warm sunny weather, instead of the continued cool, cloudy weather accompanied by light showers, that devastation would have been far more serious. It may be stated, however, that no cases of the commercial recovery of fruit was found. Individual fruits have been found in most varieties that have shown a development of new pulp cells, but this is not general enough to be of commercial importance. Instead of recovering, frozen fruit steadily deteriorates.

*The Sale of Frozen Fruit.*—A large proportion of the crop of citrus fruits was badly frozen, but in many cases only a portion of the fruit was seriously injured. Frozen fruit is known to remain

palatable and wholesome for a month or two after a freeze if properly handled. Many growers immediately gathered and shipped large quantities of such frozen oranges, but in many cases they arrived in poor condition, and the market being suspicious and overstocked, the returns were in most cases negligible. Indeed it may be stated that in very few, if any cases did the returns justify such shipments, and the loss to the growers as a whole through the injury of the market was far greater than any benefit obtained. The shipment of injured fruit was continued so long that much of it reached the consumers in dried-out, inedible condition and served to render them distrustful of the California product. The results from such shipments following the 1913 freeze were such that it can be unhesitatingly recommended that in the case of such severe freezes, no shipments of fruit should be made following the freeze, until sufficient time has elapsed to allow the separation of the good from the injured fruit.

It was thought by some growers that oranges picked promptly after the freeze and stored in cool places or placed in cold storage, where they would not dry out too rapidly and fermentation would be arrested, would remain in good condition for a much longer period than otherwise. No trial was made of this method that could be called complete and conclusive, although several experiments were made. In two cases one of the writers made an examination of navels that had been picked two or three days after the freeze and stored in a cool place in the packinghouse (not in cold storage). This examination was made in March over two months after the freeze, and the fruits were compared with navels from the same groves that had remained on the trees. In neither case could any marked difference be observed between the stored and the unstored fruits. In both cases they had dried out considerably, and the flavor had become flat and insipid.

*The Separation of Good Fruit from Frozen Fruit.*—In many groves all over the state, only a portion of the fruit was so severely frozen as to cause its drying out and decay. The good fruit in most cases was mixed on the tree with the frozen fruit and could not be separated from much of the frozen fruit by any external characters. The making of a practical segregation of such fruit became an important problem following the 1913 freeze, as it had been also in many lesser freezes. No method of separation based on the judgment of external appearances proved successful. The difference in specific gravity between frozen and sound fruit had been used as a means of making a segregation. Finally, as a result of drying out sufficient difference in specific gravity comes to exist between injured and uninjured fruits, so that a solution somewhat lighter than water, such

as denatured alcohol, guaged to the right specific gravity, will allow the heavy uninjured fruit to sink, while the lighter frozen fruit will float. For some time following the injury, no such segregation can be made. Time must be given for the changes in the fruit to take place. Lemons change more rapidly than oranges, and give a fair segregation within a month following the freeze. The changes are much slower in oranges, however, and it was about two months after the freeze before a practical segregation by this method could be obtained.

A machine had been devised to make this specific gravity segregation mechanically in alcohol, and had the previous year been installed in a few packing-houses. This machine gave fairly good results as long as the alcohol remained at the proper degree of density. Owing to the rapid evaporation of the alcohol and the change in degree of density, considerable difficulty was experienced in using these machines.

It was found that a practical and fairly economical separation could also be made by this alcoholic method, using special tanks or half barrels, into which open mesh-bottomed trays were fitted. By this method the tray filled with fruit was dipped into the alcohol. The light floating oranges could then be removed quickly by use of a sieve dipper, after which the tray could be lifted out and the heavy oranges removed.

In certain experiments, oils, such as kerosene and engine distillate, have been used instead of alcohol in making specific gravity segregations, but even when friuts so segregated have been thoroughly washed with warm water and "gold dust" to remove the oils, injury almost always ensues.

The alcoholic method of segregation was the only successful method known during the first two months following the freeze, and many were preparing to use it, regardless of the great expense for materials and the difficulty of its application. Fortunately just at this time, before much expense had been incurred in the purchase of alcohol or alcohol separators, Mr. Frank Chase of Riverside rendered citrus growers a great and lasting service by patenting a water separator and giving the patent to them for use, freely, without recompense, except that reward of personal satisfaction for work well done and the honor that comes to one from the performance of notable public service.

The principle of the Chase water separator is based on the difference in the specific gravity of the injured and uninjured fruit the same as in the case of the alcoholic separator. In the Chase separator, however, the fruits are carried in single rows and dropped from a

slight elevation, about six inches, into a current of water, moving at a regular speed. The injured, light oranges do not sink very far and come up quickly so that they are only carried a short distance before they come to the surface. The good heavy oranges sink much deeper as they fall and come to the surface more slowly so that they are carried much farther by the current of water. Taking advantage of this principle, a screen, placed horizontally at a certain depth in the water and a certain distance from the points at which the fruit falls, will allow the light, frozen oranges to arise to the surface and be carried off above the screen; while the heavy oranges will not arise until they pass the end of the screen and thus are carried on below it and into a separate receptacle, or passed directly into the washing machine in case the fruit is to be washed.

Different crops of fruit have different specific gravities, or the same fruit at different times gives a different specific gravity, so that the separating screen requires to be adjusted to the crop that is being run through at a given time. When it is properly adjusted, a very satisfactory segregation can be made, comparing favorably with the best alcoholic segregation.

The practicality of this method of segregation was immediately recognized, and separators were installed in the various packing-houses requiring them, as rapidly as the machines could be constructed. After the first of May, practically all of the fruit that was shipped from the state was run through Chase separators to eliminate injured fruit. The examination of such separated fruit, and the market reports from the separated fruit shipped, testify conclusively to the value and effectiveness of this method of separation.

# CHANGES THAT TAKE PLACE IN FROZEN ORANGES AND LEMONS*

By E. E. THOMAS, H. D. YOUNG, and C. O. SMITH

After the destruction of a large part of the citrus crop by the freeze of January 6th and 7th, 1913, it was thought to be important to make some studies of the physical and chemical changes that take place in frozen oranges and lemons. The work was carried out at the Citrus Experiment Station and was intended to determine as definitely as possible, the nature and rate of changes that take place in frozen fruit. While it is not impossible that the composition of the ash or mineral elements may be affected, it was not considered advisable to attempt to determine such changes in the time at the disposal of the investigators and only the special points which could most reasonably be expected to show variation were considered. The following points were taken up in the investigation:

The specific gravity of the fruits and of the juice.

The average weight per fruit, of good and frozen fruit.

The percentage and total amount of sugar (total sugar, sucrose and reducing sugars) and acid.

Sound fruit and badly frozen fruit of Washington navel oranges and Eureka lemons were picked every four days following the freeze for two and one-half months and these were weighed and analyzed. They were compared with sound fruit and frozen fruit picked immediately after the freeze and stored.

Four different grades of fruit were examined.

(*a*) Fruit known to be unfrozen, picked from trees whose blossoms and small fruits showed no sign of frost injury.

(*b*) Fruit which was apparently unfrozen, judging from external indications and picked from trees slightly injured by the freeze.

(*c*) Fruit supposedly frozen, picked from same tree as sample (*b*).

(*d*) Fruit picked from badly frozen trees about which there could be no question of the frost injury.

The badly frozen lemons were picked from the trees shown in figures 1 and 2.. Oranges of this grade were obtained from large navel trees in the same grove.

* A summary of these investigations was first published by one of the authors, H. D. Young, while he was employed in the Citrus Experiment Station, in a paper entitled "The Composition of Frozen Oranges and Lemons." See Jour. Ind. and Eng. Chem., vol. 7, p. 1038, Dec., 1915. For further data on same subject see article by H. S. Bailey and C. P. Wilson, "The Composition of Sound and Frozen Lemons with Special Reference to the Effect of Slow Thawing on Frozen Lemons." Jour. Ind. and Eng. Chem., vol. 8, p. 902, Oct., 1916.—H. J. Webber.

## SPECIFIC GRAVITY OF FRUITS

The work done in previous years had shown that the specific gravity of frozen fruit decreases and that the frost markings on the rind are unreliable as a means of separation (fig. 16). It was found through work done by Mr. D. C. Lefferts of Redlands, California, that frozen fruit was usually lighter in weight than sound fruit and that

Fig. 16.—Frozen and unfrozen Eureka lemons showing specific gravity of each fruit. The fruit with a specific gravity of .81 is free from frost markings and is apparently uninjured. It is, however, badly frozen. Photo by Smith, January 24, 1913.

by immersing a mixture of sound and frozen fruit in a suitable liquid, such as alcohol, the two classes could be separated. As this method of procedure proved to be fairly satisfactory, a machine was constructed for use in packing houses and a patent granted to Mr. D. C. Lefferts of Redlands and to Mr. George D. Parker of Riverside, covering the principle involved. Following the freeze of 1913 another method of separation, based on the specific gravity of frozen and unfrozen fruit was devised by Mr. Frank Chase of Riverside. (See description, page 297.)

In view of the great demand for exact information on this subject and because of its economic importance, a statistical study was made of the behavior of a number of oranges and lemons of varying degrees of injury by the frost.

Definite points on which information was desired were: (1) Do all frozen fruits have a lower specific gravity than any sound fruit? (2) If so, is the difference great enough to make it possible to separate the two classes absolutely? (3) How soon after the freeze is it possible to detect any difference that may occur? (4) What changes occur in the specific gravity of the fruit if it is picked from the tree and stored? (5) What explanation can be given of these changes?

The specific gravity of the individual fruits was found by dropping them in alcohol of varying specific gravity until that of the fruit and the alcohol was the same. Jars were prepared containing alcohol of specific gravity from .82 to .97 varying from each other by .01. The results obtained are summarized in table 5. For the sake of clearness only the figures for the best and worst fruit are presented. The intermediate classes of fruit which were only partially frozen, gave results which were in complete agreement with those presented.

TABLE 5.—*Average Specific Gravity of Fruit.*

| | Navel Oranges | | | | Eureka Lemons | | | |
|---|---|---|---|---|---|---|---|---|
| | Stored lots (a) | | Different picks (b) | | Stored lots (a) | | Different picks (b) | |
| Date | Unfrozen | Frozen | Unfrozen | Frozen | Unfrozen | Frozen | Unfrozen | Frozen |
| 1/14 | 0.876 | 0.850 | 0.876 | 0.850 | 0.890 | 0.860 | 0.890 | 0.860 |
| 18 | 0.876 | 0.840 | 0.872 | 0.846 | 0.907 | 0.833 | 0.879 | 0.834 |
| 22 | 0.884 | 0.838 | 0.874 | 0.834 | 0.926 | 0.807 | 0.889 | 0.803 |
| 26 | 0.885 | 0.832 | 0.870 | 0.820 | 0.930 | ..... | 0.887 | ..... |
| 30 | 0.884 | 0.821 | 0.864 | 0.810 | 0.941 | ..... | 0.869 | ..... |
| 2/ 3 | 0.894 | 0.812 | ..... | ..... | 0.953 | ..... | ..... | ..... |
| 7 | 0.903 | ..... | 0.873 | ..... | 0.959 | ..... | 0.881 | ..... |
| 11 | 0.914 | ..... | ..... | ..... | 0.966 | ..... | ..... | ..... |
| 15 | 0.923 | ..... | 0.880 | ..... | 0.968 | ..... | .0873 | ..... |
| 19 | 0.928 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 23 | 0.936 | ..... | 0.871 | ..... | ..... | ..... | 0.863 | ..... |
| 27 | 0.936 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 3/ 3 | ..... | ..... | 0.869 | ..... | ..... | ..... | 0.862 | ..... |
| 11 | ..... | ..... | 0.866 | ..... | ..... | ..... | 0.865 | ..... |

(a) Fruit picked on January 13th.
(b) Successive new lots picked on date given.

The first two columns in table 5 present the record of the oranges picked on January 13 and kept in storage, the specific gravity of the fruit being determined every four days. The average specific gravity of the stored navel oranges which were unfrozen incerased from .876 on the date of picking, to .936 on February 27. The average specific gravity of the badly frozen oranges in storage decreased from .850 on the date of picking to below .820 on February 3.* The third and

* A specific gravity of .820 was the lowest determined with the jars of alcohol. Where a lower specific gravity is shown in the tables it is of special fruits.

fourth columns give the specific gravities of successive new lots of oranges picked at intervals of four days. The specific gravity of these unfrozen oranges does not change appreciably, varying on both sides of .876. The specific gravity of the badly frozen oranges on the tree, however, decreased very rapidly from .850 on January 13 to below .820 on January 30. Stored lemons show the same changes in specific gravity but to a greater degree than was found in stored navel oranges. The sound lemons increased in specific gravity from .890 on January 14 to .968 on February 15, while the badly frozen lemons decreased from .860 on January 14 to below .820 on January 22. We also find that the fruits picked at different times during the experiment (columns 7 and 8), remain practically the same if unfrozen, but decreased very rapidly in specific gravity if badly frozen. We thus see that the specific gravity of the fruit which is frozen decreases rapidly whether it is picked and stored or remains on the tree and that the fruit which is unfrozen increases in specific gravity when picked from the tree and stored.

Of still more importance than the average specific gravity is that of the specific gravity of the individual fruit. It might be possible for the unfrozen fruit to have a much higher average than the frozen and yet the specific gravity be so variable among the individuals as to make a separation impossible. This is the condition for some time after the freeze. In table 6 is shown the records of individuals. The number of fruit of each density on the date of picking is shown and the number in the same lot of fruit two weeks later. The fruit was

TABLE 6.—*Number of Navel Oranges Picked on January 13, 1913 which had a Specific Gravity of Above or Below .87, and their Subsequent Changes.*

| | Unfrozen | | Frozen | |
|---|---|---|---|---|
| | .87 or above | below .87 | .87 or above | below .87 |
| Jan. 14, 1913 | 29 | 26 | 7 | 25 |
| Jan. 26, 1913 | 41 | 14 | 6 | 26 |
| Feb. 15, 1913 | 55 | 0 | 6 | 26 |

*Number of Eureka Lemons Picked on January 13, With a Specific Gravity of Above or Below .89, and their Subsequent Changes.*

| | Unfrozen | | Frozen | |
|---|---|---|---|---|
| | .89 or above | below .89 | .89 or above | below .89 |
| Jan. 13, 1913 | 61 | 3 | 12 | 32 |
| Jan. 26, 1913 | 64 | 0 | 2 | 42 |
| Feb. 15, 1913 | 64 | 0 | 1 | 43 |

Fig. 17.—Frozen and unfrozen Eureka lemons showing specific gravity of each fruit.

Photo by Smith, January 24, 1913

classed "unfrozen" and "frozen" according to its appearance on being cut.

In the fruit picked on January 13, of the fifty-five sound oranges, twenty-nine had a specific gravity of .87 or more. Of the thirty-two frozen ones, seven were also .87 or more. If, therefore, an attempt had been made to separate the sound from the frozen using .87 as the point of separation, twenty-six good fruits would have gone out with the injured ones and seven frozen ones would have been retained. Two weeks later, however, a similar separation would have recovered forty-one good oranges and six frozen ones. At the end of a month, all of the sound oranges had a specific gravity of .87 or above, while all but six of the frozen fruit were below this point. The effectiveness of holding oranges two weeks or a month after picking, before separation, is, therefore, very clearly demonstrated.

Subsequent picks illustrate the same principle. The most favorable points of separation are not constant throughout, however, nor is the percentage of recovery absolutely uniform. In the fruit picked on January 18 the separation of the oranges would have been made at .88 two weeks after picking, to eliminate all frozen fruit, and thus five sound ones would have been lost. In fruit picked on January 22 the same point, .88, would have eliminated all frozen oranges, but it would also have thrown out twenty-five out of forty-two good ones. Even a separation at .84 would have lost five good ones, while including fourteen frozen ones. In such fruit a single separation becomes inefficient. By making three grades, one below .83, the other between .83 and .87, and the third above .87, very satisfactory results could have been obtained. By January 25 the frozen fruit on the trees had so decreased in specific gravity that it was possible to eliminate it quite completely. Even at this date, however, it was not possible to prevent some loss of good fruit unless the fruit was kept in storage for some time before the separation was made. In fruit picked on January 25, sixteen of the forty-two good oranges were .84 or below, while there were three frozen ones above that figure. Two weeks later there were still seven good oranges below .84 and five frozen ones above that point.

The lemons show a much sharper line of demarcation. On the date of picking, January 13, three of the sixty-four good lemons were below .89 in specific gravity and twelve of the forty-four frozen ones were .89 or above. Two weeks later all of the good lemons had a specific gravity of .89 or above and all but two frozen fruits (one of which is shown in figure 17) were below that mark, so that a very complete separation could have been effected.

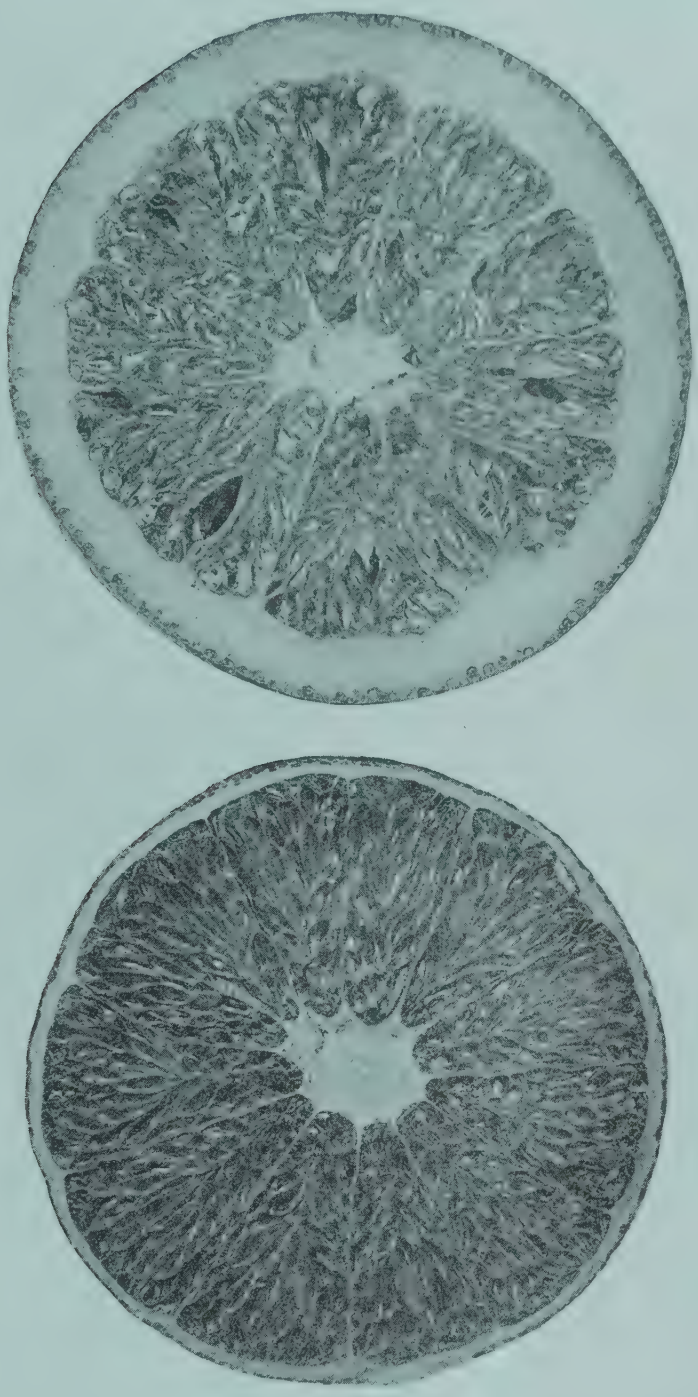


Fig. 18.—Frozen and unfrozen Navel oranges, showing difference in thickness of rind. They were the same size, 3 1/16 inches in diameter when picked, and two months later the unfrozen fruit, the one below, had a diameter of 2¾ inches while the frozen fruit had a diameter of 3 inches. Photo by Smith, March 28, 1913.

In different sections the specific gravity of the good fruit may be higher or lower than that found in the experiments here recorded, but the general conclusion will be the same in the various districts, namely, that the specific gravity of good fruit will increase in storage and that of frozen fruit will decrease.

The explanation of the change in specific gravity of sound and frozen fruit seems to be as follows: Freezing kills the walls of the cells in the fruit and so changes it from a living, semi-permeable membrane to a dead, porous mass, acting like a sponge. In the frozen fruit, therefore, connection is established between the rind and the pulp and the water which is evaporated from the outside of the rind is supplied from the pulp without the fruit suffering much diminution of volume. Losing weight and retaining approximately its original volume, it must, obviously, decrease in specific gravity. The unfrozen fruit on the other hand, loses very little, if any, moisture, except from the rind. This shrinks down very markedly and so decreases the volume of the fruit. As the weight does not decrease proportionately, the specific gravity increases. The difference in the evaporation from the rind is shown very clearly in figure 18. These two oranges were picked on January 13 and stored for two months. They were the same size, $3\frac{1}{16}$ inches in diameter, on picking. When they were cut the sound fruit had decreased to $2\frac{3}{4}$ inches while the frozen one had lost only $\frac{1}{16}$ inch, measuring 3 inches in diameter.

## SPECIFIC GRAVITY OF JUICE

It was not possible to make a determination of the specific gravity of the juice on all of the samples used on account of their large number; therefore, the data which is presented in table 3 shows a rather irregular appearance. The specific gravity of the juice of unfrozen oranges in storage does not seem to change appreciably but it remains consistently greater than that of the frozen oranges. The juice of the frozen oranges in storage had an average specific gravity of 1.046 throughout a greater part of the experiment and increased quite markedly toward its expiration. The juice of the sound oranges had an average of 1.052 which remained approximately constant. The specific gravity of the juice of frozen oranges picked at different intervals did not increase, as with frozen oranges in storage, but remained constant (see table 7).

The average specific gravity of the juice of the lemons showed about the same differences. The juice of the sound fruit had a higher specific gravity than that of the frozen. There are more irregularities

in the tables for lemons, due to the difficulty in getting samples of uniform ripeness. By January 30 the frozen lemons in storage had dried out so completely that it was no longer possible to get enough juice to determine the specific gravity. At this time twenty lemons which were picked on January 13 yielded a total of only thirty-one cubic centimeters of juice.

TABLE 7.—*Average Specific Gravity of Juice.*

| | Navel Oranges | | | | Eureka Lemons | | | |
|---|---|---|---|---|---|---|---|---|
| | Stored lots (a) | | Different picks (o) | | Stored lots (a) | | Different picks (b) | |
| Date | Unfrozen | Frozen | Unfrozen | Frozen | Unfrozen | Frozen | Unfrozen | Frozen |
| 1/14 | 1.053 | ..... | 1.053 | ..... | 1.060 | ..... | 1.060 | ..... |
| 18 | 1.052 | 1.042 | 1.052 | 1.044 | 1.042 | 1.042 | 1.048 | 1.046 |
| 22 | 1.055 | 1.044 | 1.056 | 1.046 | 1.050 | 1.041 | 1.053 | 1.046 |
| 26 | 1.047 | 1.046 | 1.055 | 1.047 | 1.045 | 1.040 | 1.044 | 1.041 |
| 30 | 1.050 | 1.045 | 1.045 | 1.040 | 1.046 | 1.038 | 1.046 | 1.037 |
| 2/ 3 | 1.051 | ..... | 1.045 | 1.043 | 1.046 | ..... | 1.040 | ..... |
| 7 | 1.056 | ..... | 1.045 | 1.045 | 1.050 | ..... | 1.045 | 1.038 |
| 11 | 1.053 | 1.044 | 1.050 | 1.048 | ..... | ..... | 1.044 | ..... |
| 15 | ..... | ..... | 1.053 | 1.048 | 1.052 | ..... | 1.042 | 1.038 |
| 19 | 1.048 | 1.050 | ..... | ..... | 1.051 | ..... | 1.042 | 1.038 |
| 23 | ..... | ..... | 1.056 | 1.042 | ..... | ..... | ..... | ..... |
| 27 | 1.055 | 1.054 | ..... | ..... | ..... | ..... | ..... | ..... |
| 3/ 3 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 11 Av. | 1.052 | 1.046 | 1.051 | 1.045 | 1.049 | 1.040 | 1.046 | 1.040 |

(a) Fruit picked on January 13th.
(b) Successive new lots picked on date given.

TABLE 8.—*Per Cent Total Sugar in Juice.**

| | Navel Oranges | | | | Eureka Lemons | | | |
|---|---|---|---|---|---|---|---|---|
| | Stored lots (a) | | Different picks (b) | | Stored lots (a) | | Different picks (b) | |
| Date | Unfrozen | Frozen | Unfrozen | Frozen | Unfrozen | Frozen | Unfrozen | Frozen |
| 1/14 | 10.56 | ..... | 10.56 | ..... | 3.39 | ..... | 3.39 | ..... |
| 18 | 9.18 | 6.54 | 8.92 | 7.86 | 2.85 | 2.47 | 2.64 | 3.16 |
| 22 | 8.87 | 7.08 | 9.43 | 7.51 | 2.88 | 2.12 | 3.12 | 2.89 |
| 26 | 8.07 | 7.28 | 9.39 | 7.44 | 2.07 | 2.41 | 2.94 | 2.47 |
| 30 | 8.32 | 7.29 | 7.50 | 6.38 | 2.83 | 2.33 | 3.67 | 2.95 |
| 2/ 7 | 9.11 | ..... | 8.09 | 6.99 | 2.71 | 3.14 | 2.57 | 1.60 |
| 15 | 9.67 | ..... | 7.85 | 7.01 | 2.69 | ..... | 2.77 | 2.24 |
| 23 | 9.17 | 7.17 | 9.00 | 8.03 | ..... | ..... | 2.96 | 2.54 |
| 3/ 3 | ..... | ..... | 10.11 | 8.82 | 2.79 | ..... | 2.57 | 2.11 |
| 7 | 9.28 | 7.96 | ..... | ..... | ..... | ..... | ..... | ..... |
| 11 | ..... | ..... | 9.41 | 6.94 | ..... | ..... | 3.30 | 2.21 |
| 15 | 8.42 | 8.63 | ..... | ..... | 2.97 | ..... | ..... | ..... |
| Average | 9.06 | 7.42 | 9.03 | 7.44 | 2.79 | 2.49 | 2.99 | 2.46 |

(a) Fruit picked on January 13th.
(b) Successive new lots picked on date given.

* The sugars were determined by Bertrand's method.

## SUGAR CONTENTS

The unfrozen oranges in storage show a variation in the amount of sugar present, but show no progressive changes, thus indicating that the variation is probably due to the difference in individual samples taken for analysis. The average of the unfrozen lots in storage was 9.06 per cent and the frozen 7.42 per cent throughout the experiment. The average percentage of sugar for the fruit picked at different dates was very close to that of the stored fruits, the difference being within the limits of experimental error. The percentage of sugar in the juice of the lemons shows the same kind of variation as was the case with the oranges (see table 8).

The great change which has been taking place in the fruit is more clearly illustrated when we consider the actual amount of sugar present in the individual fruits (table 9). While the figures for the total

TABLE 9.—*Grams of Sugar per Fruit.*

| | Navel Oranges | | | | Eureka Lemons | | | |
|---|---|---|---|---|---|---|---|---|
| | Stored lots (a) | | Different picks (b) | | Stored lots (a) | | Different picks (b) | |
| Date | Unfrozen | Frozen | Unfrozen | Frozen | Unfrozen | Frozen | Unfrozen | Frozen |
| 1/14 | 7.2 | ..... | 7.2 | ..... | 1.3 | ..... | 1.3 | ..... |
| 18 | 5.3 | 3.6 | 5.0 | 4.3 | 1.0 | 0.7 | 0.8 | 0.9 |
| 22 | 7.9 | 3.4 | 6.6 | 3.6 | 1.2 | 0.4 | 1.1 | 0.5 |
| 26 | 4.9 | 2.2 | 7.3 | 3.2 | 0.8 | 0.3 | 1.2 | 0.4 |
| 30 | 6.2 | 2.9 | 6.4 | 3.8 | 1.0 | 0.2 | 1.3 | 0.3 |
| 2/ 7 | 5.8 | ..... | 5.8 | 2.3 | 1.0 | 0.2 | 0.9 | 0.1 |
| 15 | 7.9 | ..... | 6.3 | 2.3 | 0.8 | ..... | 1.0 | 0.08 |
| 23 | 7.6 | 3.1 | 8.8 | 2.0 | ..... | .... | 1.2 | 0.08 |
| 3/ 3 | ..... | ..... | 8.0 | 2.1 | 1.0 | ..... | 1.2 | 0.2 |
| 7 | 7.0 | 1.9 | ..... | ..... | ..... | ..... | ..... | ..... |
| 11 | ..... | ..... | 8.5 | 1.9 | ..... | ..... | 0.9 | 0.08 |
| 15 | 5.1 | 1.8 | ..... | ..... | 0.9 | ..... | ..... | ..... |

(a) Fruit picked on January 13th.
(b) Successive new lots picked on date given.

amount of sugar given in grams per fruit is admittedly not exact, because of the difficulty of extracting all of the juice, yet, in view of the fact that the same size oranges, 150's, and lemons of standard ring size were used in all cases, it permits a basis of comparison that is more striking than the percentage composition. It is more important to know, for example, that on February 23rd the sound orange contained 8.8 grams of sugar, while the frozen one contained 2 grams, than it is that the percentage of sugar in the first lot was 9 per cent and in the second was 8.03 per cent. When we consider the average

amount of sugar in grams per fruit, we find that in badly frozen oranges in storage it drops to less than 2 grams per fruit against an average of 6.5 grams for an unfrozen fruit. The fruit remaining on the tree showed almost the same difference, the frozen fruit dropping to the same point, while the good fruit showed a slightly greater average than the stored fruit, or 6.9 grams. The lemons again showed the same kind of variation as is found in the oranges, but in a different

TABLE 10.—*Per Cent Invert Sugar in Juice.*

| | Navel Oranges | | | | Eureka Lemons | | | |
|---|---|---|---|---|---|---|---|---|
| | Stored lots (a) | | Different picks (b) | | Stored lots (a) | | Different picks (b) | |
| Date | Unfrozen | Frozen | Unfrozen | Frozen | Unfrozen | Frozen | Unfrozen | Frozen |
| 1/14 | 4.69 | ..... | 4.69 | ..... | 2.36 | ..... | 2.36 | ..... |
| 18 | 4.10 | 3.39 | 4.13 | 3.75 | 2.11 | 1.53 | 2.26 | 2.03 |
| 22 | 4.33 | 3.60 | 4.17 | 3.76 | 2.24 | 1.55 | 2.09 | 1.85 |
| 26 | 4.06 | 3.76 | 4.70 | 3.88 | 1.74 | 1.56 | 2.30 | 1.57 |
| 30 | 4.35 | 3.60 | 3.66 | 3.37 | 1.91 | 1.48 | 2.46 | 1.89 |
| 2/ 7 | 4.60 | ..... | 3.49 | 3.57 | 2.26 | 2.09 | 1.98 | 1.30 |
| 15 | 5.16 | ..... | 3.48 | 3.73 | 2.22 | ..... | 2.35 | 1.73 |
| 23 | 4.88 | 3.56 | 4.00 | 3.71 | ..... | ..... | 2.30 | 1.79 |
| 3/ 3 | ..... | ..... | 4.77 | 3.85 | 2.25 | 1.42 | 1.99 | 1.50 |
| 7 | 5.18 | 3.35 | ..... | ..... | ..... | ..... | ..... | ..... |
| 11 | ..... | ..... | 4.11 | 3.45 | ..... | ..... | 2.66 | 1.74 |
| 15 | 4.87 | 3.95 | ..... | ..... | 2.42 | ..... | ..... | ..... |
| Average | 4.62 | 3.60 | 4.12 | 3.67 | 2.16 | 1.60 | 2.27 | 1.71 |

(a) Fruit picked on January 13th.
(b) Successive new lots picked on date given.

TABLE 11.—*Per Cent Sucrose in Juice.*

| | Navel Oranges | | | | Eureka Lemons | | | |
|---|---|---|---|---|---|---|---|---|
| | Stored lots (a) | | Different picks (b) | | Stored lots (a) | | Different picks (b) | |
| Date | Unfrozen | Frozen | Unfrozen | Frozen | Unfrozen | Frozen | Unfrozen | Frozen |
| 1/14 | 5.87 | ..... | 5.87 | ..... | 1.03 | ..... | 1.03 | ..... |
| 18 | 5.08 | 3.15 | 4.79 | 4.11 | 0.74 | 0.94 | 0.38 | 1.13 |
| 22 | 4.54 | 3.48 | 5.26 | 3.75 | 0.62 | 0.50 | 1.03 | 1.04 |
| 26 | 4.01 | 3.52 | 4.69 | 3.76 | 0.33 | 0.85 | 0.64 | 0.90 |
| 30 | 3.97 | 3.69 | 3.84 | 3.01 | 0.92 | 0.85 | 1.21 | 1.06 |
| 2/ 7 | 4.51 | ..... | 4.60 | 3.42 | 0.45 | 1.05 | 0.59 | 0.30 |
| 15 | 4.51 | ..... | 4.37 | 3.28 | 0.43 | ..... | 0.42 | 0.51 |
| 23 | 4.29 | 3.61 | 5.00 | 4.32 | ..... | ..... | 0.66 | 0.75 |
| 3/ 3 | ..... | ..... | 5.34 | 4.97 | 0.54 | ..... | 0.58 | 0.61 |
| 7 | 4.10 | 4.61 | ..... | ..... | ..... | ..... | ..... | ..... |
| 11 | ..... | ..... | 5.30 | 3.49 | ..... | ..... | 0.64 | 0.47 |
| 15 | 3.55 | 4.68 | ..... | ..... | 0.55 | ..... | ..... | ..... |
| Average | 4.44 | 3.82 | 4.90 | 3.79 | 0.62 | 0.84 | 0.72 | 0.75 |

(a) Fruit picked on January 13th.
(b) Successive new lots picked on date given.

degree. The unfrozen lemons held in storage averaged 1 gram of sugar per fruit, while those that were frozen decreased from .7 to .2 gram per fruit. The fruit which remained on the tree showed about the same amount of variation.

The tables for invert sugar and sucrose present data that is little different from those in the total sugar (see tables 10 and 11). In other words, there seems to be practically no change in the relative amounts of the different classes of sugar present.

## ACID CONTENTS

The percentage of acid in the frozen and unfrozen oranges in storage decreased in almost the same degree. The fruit picked at different intervals showed the same change in acidity as the fruit in storage, but had a lower average. Owing to the fact that lemons have a much higher percentage of acid than do the oranges, a much greater variation is found between the unfrozen and frozen fruit. The unfrozen lemons kept in storage averaged 6.98 per cent acid throughout the experiment, while the frozen ones averaged 5.19 per cent. The acid in the fruit picked at different intervals averaged 6.27 per cent in unfrozen lemons and 4.79 per cent in frozen samples (see table 12).

TABLE 12.—*Per Cent Acid in Juice.**

| | Navel Oranges | | | | Eureka Lemons | | | |
|---|---|---|---|---|---|---|---|---|
| | Stored lots (a) | | Different picks (b) | | Stored lots (a) | | Different picks (b) | |
| Date | Unfrozen | Frozen | Unfrozen | Frozen | Unfrozen | Frozen | Unfrozen | Frozen |
| 1/14 | 1.56 | ..... | 1.56 | ..... | 5.81 | ..... | 5.81 | ..... |
| 18 | 1.56 | 1.60 | 1.45 | 1.38 | 5.70 | 5.01 | 6.64 | 4.23 |
| 22 | 1.67 | 1.62 | 1.68 | 1.49 | 6.96 | 5.34 | 7.23 | 5.02 |
| 26 | 1.47 | 1.74 | 1.69 | 1.83 | 7.54 | 4.74 | ..... | 4.67 |
| 30 | 1.68 | 1.88 | 1.53 | 1.59 | 7.67 | 4.98 | 6.49 | 3.66 |
| 2/ 7 | 1.68 | ..... | 1.50 | 1.51 | 7.00 | 5.26 | 6.53 | 4.72 |
| 15 | 1.59 | ..... | 1.31 | 1.34 | 6.72 | ..... | 6.32 | 5.18 |
| 23 | 1.40 | 1.29 | 1.22 | 1.37 | ..... | ..... | 5.64 | 4.72 |
| 3/ 3 | ..... | ..... | 1.38 | 1.15 | 7.76 | 5.79 | 6.19 | 5.73 |
| 7 | 1.19 | 1.14 | ..... | ..... | ..... | ..... | ..... | ..... |
| 11 | ..... | ..... | 1.20 | 1.21 | ..... | ..... | ..... | 5.23 |
| 15 | 1.11 | 1.20 | ..... | ..... | 7.73 | ..... | 5.65 | ..... |
| Average | 1.49 | 1.49 | 1.45 | 1.43 | 6.98 | 5.19 | 6.27 | 4.79 |

(a) Fruit picked on January 13th.

(b) Successive new lots picked on date given.

* The acid was determined by titration, using phenolphthalein as an indicator and was calculated to anhydrous citric acid.

We find again, however, that, as with sugar, the total amount of acid present decreases very markedly in the frozen fruit. The

frozen oranges showed .3 of a gram of acid per fruit, in comparison with an average of about 1 gram per fruit in unfrozen oranges. The unfrozen lemons vary to a considerable degree in the amount of acids present, ranging from 2 to 3 grams per fruit, while in the frozen fruit it practically all disappears (see table 13).

TABLE 13.—*Grams Acid Per Fruit.*

| | Navel Oranges | | | | Eureka Lemons | | | |
|---|---|---|---|---|---|---|---|---|
| | Stored lots (a) | | Different picks (b) | | Stored lots (a) | | Different picks (b) | |
| Date | Unfrozen | Frozen | Unfrozen | Frozen | Unfrozen | Frozen | Unfrozen | Frozen |
| 1/14 | 1.1 | ..... | 1.1 | ..... | 2.3 | ..... | 2.3 | ..... |
| 18 | 0.9 | 0.9 | 0.8 | 0.8 | 2.0 | 1.5 | 2.0 | 1.2 |
| 22 | 1.3 | 0.8 | 1.2 | 0.7 | 2.9 | 1.0 | 2.4 | 0.8 |
| 26 | 0.9 | 0.5 | 1.3 | 0.8 | 2.9 | 0.7 | ..... | 0.7 |
| 30 | 1.2 | 0.7 | 1.3 | 0.9 | 2.8 | 0.4 | 2.3 | 0.4 |
| 2/ 7 | 1.1 | ..... | 1.1 | 0.5 | 2.7 | 0.3 | 2.2 | 0.3 |
| 15 | 1.3 | ..... | 1.0 | 0.4 | 2.0 | ..... | 2.3 | 0.2 |
| 23 | 1.2 | 0.6 | 1.2 | 0.3 | ..... | ..... | 2.3 | 0.2 |
| 3/ 3 | ..... | ..... | 1.1 | 0.3 | 2.8 | 0.1 | 3.0 | 0.5 |
| 7 | 0.9 | 0.3 | ..... | ..... | ..... | ..... | 1.6 | 0.2 |
| 11 | ..... | ..... | 1.1 | 0.3 | ..... | ..... | ..... | ..... |
| 15 | 0.7 | 0.3 | ..... | ..... | 2.4 | ..... | ..... | ..... |

(a) Fruit picked on January 13th.
(b) Successive new lots picked on date given.

Following any severe freeze growers are confronted with the problem of whether injured fruit should be harvested immediately and used for by-products or whether the picking should be delayed until the extent of the injury becomes apparent. The rapid decrease that takes place in the amount of sugar and acid per fruit in both oranges and lemons as shown by the above tables, indicates that frozen fruit, if it is to be used for by-products should be picked and sold as soon after the freeze as possible.

## GROWTH OF FROZEN FRUIT

When fruit is badly frozen the question arises whether the tree would be harmed should the fruit remain upon the branches until it falls naturally. If the frozen fruit did not grow, but remained on the tree in the same condition as when frozen, it would presumably take little nourishment from the tree with the exception of the moisture evaportaed from the rind. In order to determine this point, several hundred Valencia oranges were marked and measured and their growth was noted each month for four months. Groves for this

work were chosen where part of the fruit was frozen while the remainder was untouched by the freeze. Different types of fruit were marked and only those with an apparently uninjured stem were selected for the experiment. In one class the fruit was green and normally would have increased in size. In another class the fruit was yellow and almost ripe and would not increase in size like the green fruit. In measuring the fruit the circumference was measured in inches. The same observations were carried on in regard to the growth of frozen lemons, and the results are given in the following table:

TABLE 14.—AVERAGE INCREASE IN CIRCUMFERENCE OF FROZEN AND UNFROZEN VALENCIAS AND LEMONS FROM JANUARY 24 TO JUNE 2, 1913

| | Good fruit, full of juice and good flavor | Fruit slightly frozen | Fruit badly frozen |
|---|---|---|---|
| | inches | inches | inches |
| Valencia, yellow fruit which was very nearly ripe at the time of the freeze | .58 | 49 | .21 |
| Valencia, fruit green; thrifty groves not badly frozen | .71 | .56 | .41 |
| Valencia, fruit green; grove badly frozen | .48 | .34 | .18 |
| Valencia, fruit almost ripe and badly frozen | .... | .33 | .10 |
| Eureka lemons—one-half of the fruit on the trees frozen | .71 | .54 | .32 |

From this table we see that the fruits have grown in circumference. In a few instances, however, the stem was found to be injured and the fruit gradually decreased in size. The juice had almost disappeared in the badly frozen fruit, leaving it hollow. In the good fruit the increase in circumference is approximately twice that of the badly frozen fruit. The rind of frozen fruits increases in thickness (fig. 19), thus probably taking nourishment, or at least water, from the tree.*

## SUMMARY

1. The specific gravity of frozen citrus fruits, in general, is lower than that of unfrozen ones. This is, however, not an absolute rule.

2. The two classes cannot be absolutely separated, but the division is sufficiently complete to make it commercially practical. Different

* *Note.*—Observations on various groves in the state lead the authors of the first article in this bulletin to conclude that no noticeable effect was produced by leaving the frozen fruits on the tree. Compare page 289. That the fruit when not too badly frozen increases in size the authors of this paper have proven. Such fruit, however, evidently losses in weight.—H. J. Webber.

machines have been perfected and are used in packing houses to make this separation.

3. Severely frozen fruit will usually show a marked decrease in specific gravity within a week; less severely injured fruit changes more slowly. In lemons the changes in specific gravity are more rapid than in oranges.

4. Holding the fruit for two weeks after picking increases the specific gravity of good fruit very markedly. A month is generally long enough to make a recognizable difference, but better separations can be obtained after six weeks or two months.

Fig. 19.—Badly frozen orange showing growth of rind when fruit remains on tree. Photo by Smith, March 7, 1913.

5. Frozen fruit decreases in specific gravity whether stored or left on the tree. Sound fruit, however, remains fairly constant on the trees, but gradually increases in density when stored.

6. The excessive loss of moisture in citrus fruits caused by freezing is due to the killing of the walls of the cells in the fruit, thus changing them form semi-permeable membranes to a porous substance that freely allows the liquid to evaporate from the interior without decreasing its volume. This loss in weight and not in volume decreases the specific gravity.

7. The specific gravity of the juice of frozen citrus fruit is somewhat lower than that of the unfrozen.

8. The total amount of sugars decreases in frozen fruit. The average amount in unfrozen oranges of size 150's being 6.5 grams, while in those that are frozen it decreases to less than 2 grams. The same holds true with lemons. Unfrozen lemons of standard ring size have an average of 1 gram per fruit, while those that are frozen decrease from .7 to .2 gram per fruit.

9. No change was found in the relative amounts of the different sugars present.

10. The per cent of acid in the juice of frozen citrus fruits decreases slightly when compared with the unfrozen. The weight of acid per fruit in unfrozen fruit remains nearly constant, while in that which is frozen it continues to decrease until practically none remains.

11. Frosted citrus fruits that remain on the tree continue to increase in size, this development being a thickening of the rind.

# A TEST OF THE EFFICIENCY OF ORCHARD HEATING

By A. D. SHAMEL, L. B. SCOTT, and C. S. POMEROY

United States Department of Agriculture

The serious damage done by the freeze of 1913 awakened a general interest in ways and means for protecting citrus orchards from this danger. In many sections various means of protection were in use during the freeze, but exact figures were lacking in many cases as to the profitableness of the heating methods used.

The opportunity of securing some practical information in an experimental way on the results that had been obtained seemed too good to lose. Consequently the writers in co-operation with Dr. H. J. Webber of the Citrus Experiment Station of the University of California decided to secure data on this subject in connection with their citrus performance-record work for the improvement of citrus fruits by bud selection.

After consultation it was decided to confine observations to lemon varieties and to orchards located in the Corona district. In this district an unusual number of groves were protected by heaters during the freeze, and in many cases unprotected orchards adjoined the protected ones.

Shortly after the freeze, a committee of Corona lemon growers, Dr. H. J. Webber, and the writers visited most of the lemon groves in the Corona district for the purpose of determining whether or not reliable data on the efficiency of the methods of orchard protection could be obtained. After a careful survey of the situation, it was unanimously decided that such information could be secured under fair and comparable conditions. Therefore, several orchards were selected for study and observation that in the opinion of every one in the party were suitable for this purpose.

The plan of study agreed upon was to keep performance-records of comparable plots of trees in heated and unheated groves, beginning with the first pick after the frost and continuing for at least one year, and if advisable for a longer period of time.

It was soon apparent that lemon varieties differ in their resistance to frost. So it became necessary to compare heated and unheated orchards of the same variety. Not only was this difference very evident, but different types in the same variety apparently differ in resistance to frost, so that it became necessary to compare trees of the same type in heated and unheated groves.

Fig. 20.—The effect of the freeze on unheated Lisbon lemon tree. Compare fig. 21.

In view of the great amount of detailed record-keeping involved for each individual tree, it was found necessary to limit the number of trees for observation. In order to combine reliability of data and limit the number of trees to the smallest possible number, the following plan of plot arrangement was carried out. First, comparable orchards were selected. Then a plot of ten trees in each orchard was arranged on the following basis: Two adjoining trees were marked for observation. Counting these trees as numbers 1 and 2, respectively, the ninth and tenth trees in the same row were also marked. Corresponding trees, ten rows from this row, were then marked, so that the marked trees were the two end trees in a square of one hundred trees. In addition to these eight trees, two trees in the middle of the square were also marked, thus completing the plot.

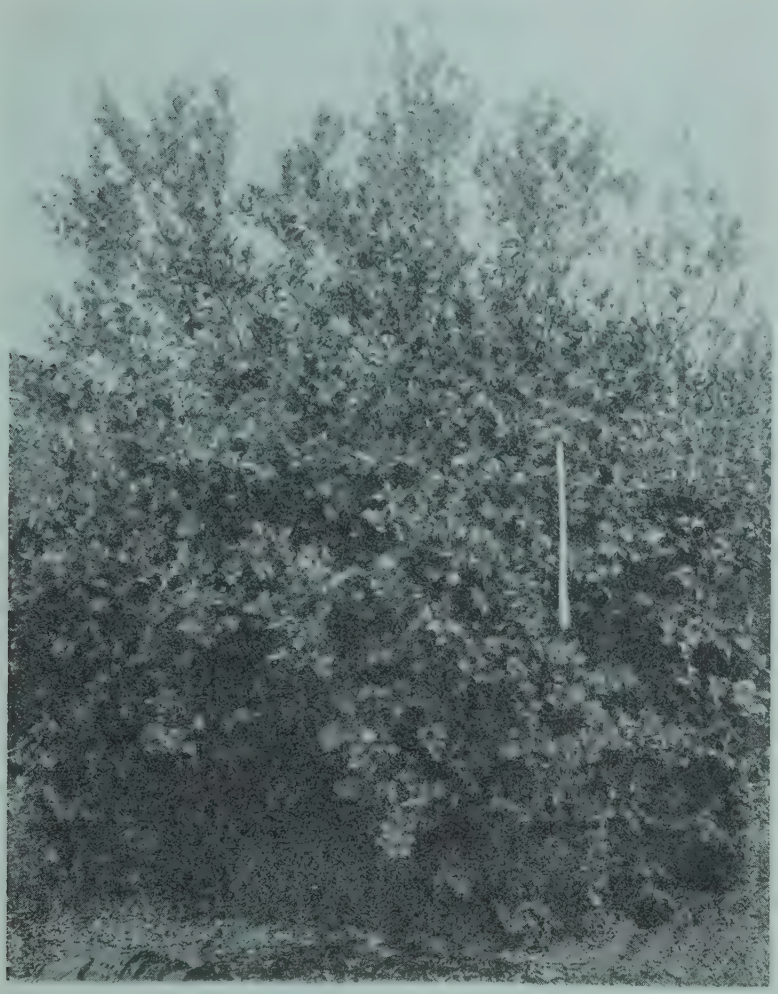


Fig. 21.—Lisbon lemon tree in grove heated with one stove per tree, crop and tree practically uninjured. Compare fig. 20.

This plot arrangement is illustrated by the following diagram:

RECORD PLOT ARRANGEMENT

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | × | × | × | × | × | × | 3 | 4 |
| × | × | × | × | × | × | × | × | × | × |
| × | × | × | × | × | × | × | × | × | × |
| × | × | × | × | × | × | × | × | × | × |
| × | × | × | × | 5 | 6 | × | × | × | × |
| × | × | × | × | × | × | × | × | × | × |
| × | × | × | × | × | × | × | × | × | × |
| × | × | × | × | × | × | × | × | × | × |
| × | × | × | × | × | × | × | × | × | × |
| 7 | 8 | × | × | × | × | × | × | 9 | 10 |

The figures in the diagram represent the locations of trees studied.

This arrangement eliminated the personal equation in tree selection, care being taken that the trees of a given variety were of the same general type. Great care was also used to prevent other influences on production than the heating methods used from interfering with the results. Naturally, all observable influences on individual tree-production which might tend to interfere with the results or modify them were considered in locating the plots. From our experience

Fig. 22.—The effect of the freeze on unheated Eureka lemon tree. Such trees have since recovered, but two years' crops were lost.

with these plots since their selection, we feel sure that the results represent fairly the influences of heating as compared with no heating.

The crops from all the trees were picked at regular intervals for one year. After completing one year's data, it was decided that it was unnecessary to continue records in all of the plots for a second year. Two plots, one heated and one not heated, were selected for the second year's data, and records from all of the other plots were discontinued. The difference in production between the heated and unheated plots was found to be considerable the second year.

During the experiment each tree was picked separately. The fruits were sorted into four grades—green, tree-ripe, frozen, and culls.

After sorting, the fruits of each grade were counted and weighed. The percentage of each of these four grades of fruit produced on each plot is given in the following table, and is self-explanatory.

The average cost of heating in the orchards where the plots were located has also been secured from records kept by the growers for this purpose.

TABLE 15

PERCENTAGES OF DIFFERENT GRADES OF FRUIT ON EACH PLOT.

Figures based on *weight* of fruit in the crop of the year.

LISBONS

| *Heated Plots* | | | *Unheated Plots* |
|---|---|---|---|
| 61.4% | Green | 19.2% | |
| 26.5% | Tree Ripe | 4.8% | |
| Plot 4 10.6% | Frozen | 74.3% | Plot 1 |
| 1.6% | Culls | 1.6% | |
| 74.4% | Green | 31.3% | |
| 17.1% | Tree Ripe | 1.6% | |
| Plot 6 6.5% | Frozen | 66.8% | Plot 8 |
| 2.1% | Culls | 0.2% | |
| 57.2% | Green | 10.5% | |
| 39.4% | Tree Ripe | 6.1% | |
| Plot 9 1.6% | Frozen | 83.2% | Plot 10 |
| 1.9% | Culls | 0.2% | |

Average of the three series.

| | | |
|---|---|---|
| 64.3% | Green | 20.4% |
| 27.7% | Tree Ripe | 4.2% |
| 6.2% | Frozen | 74.8% |
| 1.9% | Culls | 0.7% |

EUREKAS

| | Plot 7 *Well heated* | Plot 5 *Poorly heated* | Plot 3 *Unheated* |
|---|---|---|---|
| Green | 50.7% | 39.9% | 32.3% |
| Tree Ripe | 43.2% | 42.4% | 7.3% |
| Frozen | 2.6% | 14.1% | 58.0% |
| Culls | 3.5% | 3.6% | 2.4% |

UNHEATED EUREKAS VS UNHEATED LISBONS

| *Unheated Eurekas* | | *Unheated Lisbons* | |
|---|---|---|---|
| 32.3% | Green | 49.5% | |
| 7.3% | Tree Ripe | 7.8% | |
| Plot 3 58.0% | Frozen | 40.7% | Plot 2 |
| 2.4% | Culls | 2.1% | |

Both plot 3 and plot 2 were partially protected by heaters in neighboring groves

TABLE 16

RETURNS PER ACRE, F.O.B. PACKING HOUSE.

LISBONS

| *Heated Plots* | *Unheated Plots* |
|---|---|
| *Plot 4* | *Plot 1* |
| $1759.59 | $424.22 |
| *Plot 6* | *Plot 8* |
| $888.00 | $300.98 |
| *Plot 9* | *Plot 10* |
| $2563.46 | $128.15 |
| Average of the three series | |
| $1737.02 | $284.45 |

EUREKAS

| *Plot 7* | *Plot 5* | *Plot 3* |
|---|---|---|
| *Well Heated* | *Poorly Heated* | *Unheated* |
| $1423.06 | $768.47 | $352.54 |

UNHEATED EUREKAS VS UNHEATED LISBONS

| *Plot 3* | *Plot 2* |
|---|---|
| *Unheated Eurekas* | *Unheated Lisbons* |
| $352.54 | $1126.35 |

Plots 3 and 2 were partially protected by heaters in neighboring groves.

TABLE 17

AVERAGE COST OF HEATING PER ACRE ON ALL HEATED PLOTS IN THE EXPERIMENTS

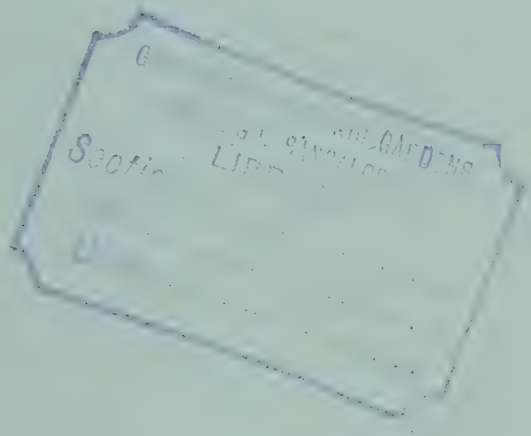
| | | |
|---|---|---|
| Stoves | | |
| Cost | $53.29 | |
| Interest | 3.20 | |
| | $56.49 | |
| Depreciation, 33⅓% | | $18.78 |
| Reservoir and pipe lines | | |
| Cost | $32.82 | |
| Interest | 1.97 | |
| | $34.79 | |
| Depreciation, 10% | | 3.48 |
| Oil used | | 57.95 |
| Filling pots, lighting and refilling | | 21.09 |
| | Total average cost | $101.30 |

The value of the fruit in the different plots, computed to the acre basis, was secured through the owners of the orchards who furnished the figures of the actual returns for this fruit during the period of observation, and it, together with the average cost of heating, will be found summarized in tables 16 and 17.

The writers do not believe it to be necessary for them to comment on the results, as the tables are self-explanatory. They hope that it may prove to be of some value, in that it shows the actual behavior of heated and unheated Eureka and Lisbon lemon trees in the Corona district for the year following the freeze.

The observations presented here were made possible by the hearty co-operation of the lemon growers owning the orchards in which experiment plots were located. All of the expense of picking, loss of fruit due to cutting, information as to cost of heating, value of crop, and other factors have been furnished by these growers.

The writers' only concern has been to secure reliable data to add to the subject of the practical value of orchard protection as a whole.



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# THE INFLUENCE OF BARLEY ON THE MILK SECRETION OF COWS

BY
F. W. WOLL AND E. C. VOORHIES

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# THE INFLUENCE OF BARLEY ON THE MILK SECRETION OF COWS

By F. W. WOLL and E. C. VOORHIES

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Barley is one of the standard feeds for horses, cattle, hogs and sheep in this state, as in most of the Western states, and is also frequently used as a part of the grain rations for dairy cattle and poultry. There is a certain prejudice against the use of this cereal for milch cows among some dairy farmers, who believe that it has a tendency to dry up the cows, but the nutritive effect of the cereal and its high value for stock feeding are otherwise generally recognized by our farmers. The influence of barley on the milk secretion of cows in the University dairy herd has been studied during the past few years and the results of this investigation are given in the following pages.

## EXPERIMENTS WITH GRADE HOLSTEIN

In taking up this question for study, it was decided to feed barley as the sole concentrate to a good type of a dairy cow for several lactation periods, in addition to alfalfa hay or alfalfa and silage. The plan was to feed barley heavily during this time, up to the limit of the cow's acceptance, so as to secure as conclusive evidence as possible with regard to the cumulative effect of this cereal and this method of feeding on the milk flow. The cow selected for this experiment, a grade Holstein named Hannah, had been in the University dairy herd for a year previous to the trial. She was purchased by the University in July, 1913, was about four years old at that time, and weighed slightly over 1200 pounds. She dropped a bull calf on July 16, shortly after her arrival in the herd. Hannah is a strong, healthy animal; she has always been in the best of health and condition while in the herd, and has repeatedly been placed on experiments which did not interfere with that here outlined. Her feed record for the year prior to the barley feeding is complete up to January 1, 1914, so far as kinds of feeds are concerned. Since that time, the amounts of feed eaten are known for her as well as all other cows in the University dairy herd.

The milk yielded by the cow was weighed throughout the lactation period, and weekly composite samples of the milk were taken and tested for total solids and butterfat. The effect of the grain feeding on the body condition and the general health of the cow was also carefully noted. Table I shows the production and the feed consumed by this cow during five consecutive lactation periods, 1913–18. During the middle three years, 1914–17, she was fed barley as a sole concentrate, and during the first and the last year of the trial mixtures of common grain feeds, the roughage fed throughout the trial being alfalfa hay or green alfalfa, and Indian corn or sorghum silage.

TABLE Ia

PRODUCTION OF HANNAH, 1913–18

| Year | Dates of calving | Days in milk | Lbs. milk | Lbs. butterfat | Per cent butterfat | Ave. body weight lbs. | Character of grain feed |
|---|---|---|---|---|---|---|---|
| 1913–14 | July 16,'13 | 274 | 8,246.2 | 269.11 | 3.27 | 1,231 | Mixed |
| 1914–15 | May 27,'14 | 350 | 12,806.1 | 432.77 | 3.37 | 1,276 | Barley |
| 1915–16 | June 30,'15 | 308 | 11,859.5 | 373.11 | 3.15 | 1,349 | Barley |
| 1916–17 | June 14,'16 | 323 | 9,605.4 | 315.74 | 3.29 | 1,439 | Barley |
| 1917–18 | July 23,'17 | 317 | 9,535.5 | 325.06 | 3.41 | 1,445 | Mixed |

TABLE Ib

FEED CONSUMPTION BY HANNAH PER LACTATION PERIOD, IN LBS.

| Feeds | 1913–14* | 1914–15 | 1915–16 | 1916–17 | 1917–18 | Average 1914–17 (barley only) |
|---|---|---|---|---|---|---|
| Alfalfa hay | ..... | 4,674 | 4,551 | 5,482 | 4 931 | ..... |
| Alfalfa, green | ..... | 6,836 | 5,331 | 2,378 | 855 | ..... |
| Indian corn, green | ..... | 317 | 359 | ..... | 195 | ..... |
| Indian corn, silage | ..... | 1,570 | 6,537 | 6,564 | 8,591 | ..... |
| Sorghum silage | ..... | 3,437 | ..... | ..... | 1,587 | ..... |
| Sudan grass silage | ..... | ..... | ..... | 650 | ..... | ..... |
| Barley | ..... | 3,059 | 2,917 | 2,350 | 483 | ..... |
| Wheat bran | ..... | ..... | ..... | ..... | 292 | ..... |
| Oats | ..... | ..... | ..... | ..... | 24 | ..... |
| Cocoanut meal | ..... | ..... | ..... | ..... | 336 | ..... |
| Dried beet pulp | ..... | ..... | ..... | ..... | 1,015 | ..... |
| Cottonseed meal | ..... | ..... | ..... | ..... | 46 | ..... |
| Total concentrates | ..... | 3,059 | 2,917 | 2,350 | 2,917 | 2,775 |
| Average daily grain | ..... | 8.7 | 9.5 | 7.3 | 6.9 | 8.5 |
| Feed units, roughage | ..... | 4,177 | 4,156 | 4,283 | 4,308 | 4,205 |
| Feed units, concentrates | ..... | 3,059 | 2,917 | 2,350 | 2,197 | 2,775 |
| Total feed units | ..... | 7,236 | 7,073 | 6,633 | 6,505 | 6,980 |

* Amounts of feed eaten known only during latter half of lactation period; fed alfalfa (green or hay), corn silage and concentrates (barley, oats, bran, linseed meal, cocoanut meal, in varying mixtures) during the year.

The table shows the dates of freshening during the progress of the experiment; days in milk for each lactation period; production of milk and butterfat, with average percent of fat, body weight, and feed consumed. It will be seen that Hannah's production during the first lactation period on barley was increased by about 4560 pounds of milk and 164 pounds of butterfat over that of the preceding period —an increase of 55 per cent and 61 per cent, for milk and butterfat respectively. This increase was of course primarily due to the heavy grain feeding practiced during this year. Up to March, 1914, Hannah received rough feeds only, alfalfa hay and corn silage, to which a daily allowance of five pounds of mixed grain feeds (barley, oats, linseed meal and cocoanut meal) was added after March 5. During the greater portion of the first year of barley feeding, on the other hand, she received ten pounds of barley daily, and seven to eight pounds during the last four months of the lactation period. While she was offered and ate as much as fifteen pounds of barley daily for a few weeks during the following lactation period, it was found that ten pounds a day was ordinarily her limit, and this amount was rarely exceeded even at the flush of her production when she produced over two pounds of butterfat daily. She remained in milk considerably longer this lactation period than during the preceding year, viz., 350 days, and her body weight was, on the average, forty-five pounds heavier during the barley feeding than while on mixed grain the preceding period.

During the following two lactation periods the feeding of barley as exclusive grain feed was continued; the amount of milk produced during these two periods was somewhat lower than during the preceding year, but considerably above the yield for the mixed grain period, and the same holds true also for the production of butterfat during these periods. If the average production by the cow during the three lactation periods when she was fed barley as sole concentrate be compared with the corresponding averages for the preceding and the following periods when mixed grain was fed, it will be found that her milk production during the barley periods was 2533 pounds, or 28.5 per cent, higher than when she was fed mixed grain, and her average production of butterfat was increased by seventy-five pounds, or 25.3 per cent. Her lactation periods during 1914–17 were thirty-one days (10 per cent) longer, on the average, than during the mixed grain feeding, and she weighed an average of twenty-nine pounds heavier during the intermediate periods than when fed mixed grain rations.

The average yields of butterfat by the cow for each day in milk

during the five lactation periods, 1913–18, were .98, 1.23, 1.21, .98, and 1.03 pounds, the average for the barley period being 1.14 pounds, which is 13 per cent above the average for the mixed grain period. Since the amount of grain and roughage eaten during the first lactation period, 1913–14, is not known, no definite comparison can be made between the feed consumption and the dairy production of the cow during the five-year period. However, as grain was fed only during the latter part of the first lactation period, the amount of mixed grain eaten, and the total or daily feed consumption must have been considerably lower this period than during the first year of barley feeding. The average amount of barley eaten daily for the periods 1914–17 was 8.5 pounds, against 6.9 pounds of mixed grain the following year. The average number of feed units in the barley rations was 6980, or 7.3 per cent above that furnished in the last mixed grain period, 1917–18. It seems evident, therefore, that the increase in production during the barley periods, as compared with the yields on mixed grain feeding, came largely as a result of the heavier rations fed, especially of grain, during the barley periods.

There is nothing in the results obtained on the experiment with this cow that would indicate that an exclusive or even a heavy, long-continued feeding of barley has any deleterious influence on the milk secretion of the cow; on the contrary, the production was greatly increased on barley feeding; her lactation periods were about a month longer, on the average; she weighed heavier when fed barley than when receiving mixed-grain rations, and she was in perfect health and maintained an excellent appetite throughout the whole feeding period. The effect of the exclusive barley feeding was therefore beneficial in every respect.

### EXPERIMENT WITH TWO PURE-BRED COWS

Similar data to those given in the preceding pages have been obtained during the past three years for complete lactation periods for two pure-bred cows, one Jersey and one Holstein, and for a considerable number of cows for a fraction of a lactation period. The experiments with the former cows were not conducted primarily for the purpose of trying out the effect of exclusive barley feeding on their milk production; the cows on this experiment had hardly come up to the expectations of this class of dairy animals and they were changed to a barley-alfalfa-silage diet to ascertain whether this would tend to render them less profitable dairy producers than they had proved under the system of feeding ordinarily practiced in the dairy herd.

The cows placed on this experiment were Roxey Mercedes Queen 2d, 144605 (Holstein) and University Marigold, 282343 (Jersey).

*Roxey* was purchased by the University in 1911 as a two-year-old; she produced 4694.5 pounds of milk and 192.91 pounds of fat (4.11 per cent) during her first year in the University dairy herd; her

TABLE IIA

PRODUCTION OF PURE-BRED COWS FED BARLEY, 1915–17

| Year | Dates of calving | Days in milk | Lbs. milk | Lbs. butterfat | Per cent butterfat | Ave. body weight lbs. | Character of grain feed |
|---|---|---|---|---|---|---|---|
| | *Roxey Mercedes Queen 2d, 144605* | | | | | | |
| 1913–14 | Dec. 23,'13 | 351 | 9,813.2 | 380.25 | 3.87 | 1,280 | Mixed |
| 1915 | Jan. 8,'15 | 335 | 7,736.9 | 308.34 | 3.98 | 1,249 | Barley |
| 1916 | Jan. 1,'16* | 362 | 9,027.2 | 342.96 | 3.80 | 1,338 | Mixed |
| 1917 | Mar. 3,'17 | 270 | 7,243.1 | 296.28 | 4.09 | 1,361 | Mixed |
| | *University Marigold, 282343* | | | | | | |
| 1914–15 | Apr. 28,'14 | 462 | 6,509.5 | 356.38 | 5.47 | 883 | Mixed |
| 1915–16 | Sept. 19,'15 | 315 | 4,332.2 | 252.80 | 5.97 | 911 | Barley |
| 1916–17 | Aug. 29,'16 | 296 | 4,197.7 | 254.09 | 6.05 | 970 | Mixed |

* Aborted.

TABLE IIB

FEED CONSUMPTION, PER LACTATION PERIOD, IN POUNDS

| | Roxey | | | | Marigold | | |
|---|---|---|---|---|---|---|---|
| | 1913–14 | 1915 | 1916 | 1917 | 1914–15 | 1915–16 | 1916–17 |
| Alfalfa hay | 4,424 | 4,144 | 7,253 | 4,416 | 5,862 | 5,773 | 4,843 |
| Alfalfa green | 8,111 | 7,509 | 3,055 | 2,876 | 11,705 | 1,701 | 1,727 |
| Indian corn, green | 387 | 934 | ..... | 194 | 165 | 575 | ..... |
| Indian corn, silage | 2,487 | 1,125 | 5,208 | 4,352 | 1,430 | 4,568 | 5,287 |
| Sorghum silage | ..... | 2,648 | ..... | 432 | 2,441 | ..... | 1,260 |
| Oat silage | ..... | 1,575 | ..... | ..... | 1,540 | ..... | ..... |
| Sudan grass silage | ..... | ..... | 670 | ..... | ..... | ..... | 650 |
| Green barley | 1,690 | ..... | ..... | ..... | ..... | ..... | ..... |
| Roots | 412 | ..... | ..... | ..... | ..... | ..... | ..... |
| Wheat bran | 879 | ..... | 198 | 164 | 572 | ..... | 192 |
| Barley | 1,106 | 2,157 | 471 | 364 | 2,091 | 1,711 | 253 |
| Oats | 437 | ..... | ..... | 29 | 253 | ..... | 5 |
| Milo | ..... | ..... | 46 | ..... | ..... | ..... | ..... |
| Linseed meal | 161 | ..... | 11 | ..... | 108 | ..... | ..... |
| Cocoanut meal | 117 | ..... | 200 | 476 | 104 | ..... | 377 |
| Dried beet pulp | 692 | ..... | 278 | 1,036 | 210 | ..... | 575 |
| Cottonseed meal | ..... | ..... | 18 | 66 | ..... | ..... | 54 |
| Total grain feed | 3,392 | 2,157 | 1,222 | 2,135 | 3,338 | 1,711 | 1,456 |
| Average per day | 9.7 | 6.4 | 3.4 | 7.9 | 7.2 | 5.4 | 4.9 |
| Feed units, roughage | 3,868 | 3,890 | 5,042 | 3,437 | 5,524 | 3,962 | 3,867 |
| Feed units, concentrates | 3,392 | 2,157 | 1,222 | 2,135 | 3,337 | 1,711 | 1,456 |
| Total feed units | 7,260 | 6,047 | 6,264 | 6,572 | 8,862 | 5,673 | 5,323 |

production during subsequent years is given in table II. She was admitted to the Advanced Register of the Holstein-Friesian Association on the basis of an official seven-day record, January 5 to 12, 1914, of 339.2 pounds of milk and 13.540 pounds butterfat (A. R. O., No. 26364). Roxey was of a blocky build and was a poor type of a Holstein, in spite of her good seven-day record; as she proved an uncertain breeder she was sold for beef in December, 1917, after a lactation period of only 270 days, during which she produced 7243 pounds of milk and 296.3 pounds butterfat.

*University Marigold,* No. 282343, was bred by the University of California (born September 8, 1911). She has an official record of 5566 pounds of milk and 319 pounds butterfat for the year ending April 29, 1915 (mixed-grain ration. See table II). She did not get in calf after freshening August 17, 1917, and was sold for beef in April, 1918.

The results presented in table II will only be discussed here as regards their bearing on the effect of barley feeding on the production of the cows. It will be noted that the production of these cows during the periods when barley was fed as exclusive grain feed did not show a similar improvement in production over the mixed grain periods as in the case of the grade cow, Hannah. Roxey produced about 18 per cent less milk and 15 per cent less butterfat during the barley periods than on the mixed grain rations, the corresponding figures for Marigold being 19 per cent and 17 per cent less. The average daily production of butterfat during the barley periods was 9 per cent and 2 per cent lower than when mixed grain was fed, for Roxey and Marigold, respectively.

The amounts of barley fed these cows were considerably smaller than in the case of Hannah, viz., on the average, 6.4 pounds daily for Roxey and 5.4 pounds for Marigold, and the rations fed during the barley periods contained in both cases less grain and less total feed materials than during the corresponding mixed-grain periods. The decreased dairy production by the cows during the former periods is, therefore, only what might be expected. The length of the lactation periods when barley was fed was fully normal in the case of both cows.

The evidence furnished by the trials with these cows at first thought might be taken to indicate that the feeding of barley as sole grain feed was responsible for the decreased dairy production during the barley periods. If the conditions of the trials and the relation of feed consumption to production be studied, however, it will be readily seen that such a conclusion is not warranted and that barley feeding appar-

ently did not have any undesirable effect on these cows any more than in the case of Hannah, either in so far as the production or the health and thriftiness of the animals are concerned.

### FEEDING BARLEY DURING BRIEF PERIODS

As previously stated, a number of cows in the University dairy herd have been fed barley as sole concentrate during brief periods, mostly five weeks in each case, during the last two years. It is of interest to determine in how far the substitution of barley for mixed grain in the rations of the cows affected the production and body weights of the cows. The dairy records for these cows have therefore been compiled, the data for the weeks when barley was fed being compared with the averages of the corresponding preceding and following weeks when mixed grain was fed. None, or but slight, changes occurred in the kinds or amounts of roughage fed during these periods. The results of these compilations are presented in table III.

A study of the data presented in the table will disclose the fact that the amounts of milk produced on the barley rations were higher than those produced on the mixed-grain rations in the case of twelve

TABLE III

PRODUCTION BY COWS FED BARLEY OR MIXED GRAIN DURING CORRESPONDING PERIODS

| | Fed barley as exclusive concentrate | | | | | Fed mixed grain | | | |
|---|---|---|---|---|---|---|---|---|---|
| Name of cow | Days from calving | Lbs. milk | Lbs. fat | Average per cent fat | Body weight lbs. | Lbs. milk | Lbs. fat | Average per cent fat | Body weight lbs. |
| Korndyke | 358 | 487.7 | 19.04 | 3.9 | 1,480 | 478.3 | 18.58 | 3.9 | 1,447 |
| Whittie | 105 | 793.8 | 28.99 | 3.7 | 997 | 763.5 | 27.27 | 3.6 | 998 |
| Bess 2d | 96 | 900.5 | 34.53 | 3.8 | 1,227 | 844.9 | 32.41 | 3.8 | 1 215 |
| Blackie | 228 | 284.6 | 13.62 | 4.8 | 1,288 | 264.4 | 11.48 | 4.3 | 1,276 |
| Helen | 130 | 718.1 | 26.48 | 3.7 | 1,433 | 774.1 | 28.66 | 3.7 | 1,410 |
| Lulu | 248 | 561.5 | 23.12 | 4.1 | 1,172 | 569.7 | 23.69 | 4.2 | 1,179 |
| La Polka | 195 | 539.6 | 19.32 | 3.6 | 1,371 | 528.4 | 19.86 | 3.8 | 1,395 |
| Queen | 280 | 610.9 | 20.15 | 3.3 | 1,448 | 649.9 | 20.64 | 3.2 | 1,449 |
| Roanee | 137 | 881.2 | 31.66 | 3.6 | 985 | 800.7 | 28.33 | 3.5 | 963 |
| Colantha | 293 | 394.4 | 13.34 | 3.4 | 963 | 375.7 | 12.50 | 3.3 | 948 |
| Peggy | 86 | 1,274.2 | 46.53 | 3.7 | 1,009 | 1,241.8 | 42.13 | 3.4 | 1,001 |
| Woodland | ..... | 613.2 | 27.62 | 4.5 | 1,157 | 577.0 | 27.02 | 4.7 | 1,164 |
| Bess Lass | 51 | 542.6 | 18.76 | 3.5 | 1,045 | 486.9 | 16.50 | 3.4 | 1,031 |
| Mermaiden 2d | 191 | 513.3 | 24.13 | 4.7 | 791 | 468.5 | 20.37 | 4.3 | 790 |
| Fern | 136 | 325.8 | 16.93 | 5.2 | 941 | 317.8 | 16.34 | 5.1 | 957 |
| Totals and averages | 181 | 9,441.4 | 364.22 | 3.86 | 1,154 | 9,141.6 | 345.78 | 3.78 | 1,148 |
| Difference | | +299.8 | +18.44 | + .08 | +6 | ..... | ..... | ..... | ..... |

cows, and the lower in the case of three cows; the amounts of butterfat were higher in eleven cases and lower in four cases, and the average body weights of the cows were higher in nine cases and lower in six cases; finally, the percentages of fat were higher during the barley periods in nine cases and lower in three cases than during the mixed-grain periods (no appreciable change in three cases). Considering the average data for all fifteen cows, it will be seen that there was an increase of 3 per cent in the total amount of milk produced, of 5 per cent in the amount of butterfat produced, and of 6 pounds in the body weights of the cows, on the barley rations as compared with the mixed-grain rations. The average fat content of the milk produced on the former rations was, furthermore, slightly improved (.08 per cent) over that of the milk produced when the cows were fed mixed grain.

These average differences are not very marked; only in the case of two cows was the milk production improved by more than 10 per cent during the barley feeding over that of the preceding and following mixed-grain periods, and the fat production was increased by more than 10 per cent during the former periods in the case of four cows. The conclusion might be justified under these conditions that the slight improvement in production in the case of these fifteen cows came as a result of substituting barley for mixed grain, but it is also possible, in fact more likely, that the differences in production observed may lie within the limits of experimental errors in trials of this kind, and that they cannot therefore be interpreted to indicate a higher nutritive effect of rolled barley above that of the mixtures of standard concentrates fed to these cows. Whichever explanation is accepted, it is very clear, however, that the results of the last trials furnish positive evidence that barley has no tendency to decrease the milk production of the cows in comparison with that secured by feeding similar amounts of common grain mixtures, and that the feeding of barley to dairy cows is not accompanied by deleterious effects of any kind. Like the testimony previously presented by the five-year trial with the grade cow, Hannah, and by the trials with the two pure-bred cows, the results obtained in these short-period trials show that barley is an excellent feed for milch cows, and that when fed with alfalfa, or with alfalfa and silage, the production of the cows is at least equal to that secured on rations made up of similar rough feeds and mixtures of standard grain feeds, like wheat bran, oil meals, beet pulp, etc.

In several of the trials reported, somewhat better results were obtained during the barley periods than when mixed concentrates were fed; in nearly all of these cases the total amounts of feed eaten by the cows in the former rations were, however, larger than in those of

the latter. The data secured in the trials can hardly be interpreted to show that barley is a more efficient component of rations for dairy cows than similar amounts of mixed standard grain feeds; experience has taught dairy farmers that variety is a very desirable quality in the feed ration, and tends to insure a good, healthy appetite, and a large dairy production.

### FEEDING VALUE OF BARLEY

There is every reason to consider barley a most valuable stock feed. It is the common bread-grain in northern European countries, and its high nutritive value for man and beast is generally recognized there as elsewhere. It is one of the standard grain feeds for dairy cattle and other farm animals in the Scandinavian countries and is also used as a feed for farm stock, including poultry, in many other parts of Europe and in northern Africa. Barley is the common grain fed to the Arab horses, among others—a breed noted for its vigor and endurance. Without entering into a discussion of the constitution of the various feed components in the various cereals, we may say that barley does not greatly differ from other cereal grains in either chemical composition, digestibility or nutritive effects, as will be seen from the following table. The figures given in the table show that, so far as digestible nutrients or net energy values are concerned, this cereal ranks with Indian corn, rye and wheat.

TABLE IV

CHEMICAL COMPOSITION, DIGESTIBLE NUTRIENTS, AND ENERGY VALUES OF CEREAL GRAINS, IN PERCENT

| | Moisture | Protein | Fat | Fiber | Nitrogen-free extract | Ash | Digestible | | Net energy values, therms |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Protein | Carbohydrates and fat | |
| Barley | 10.8 | 12.0 | 1.8 | 4.2 | 68.7 | 2.5 | 9.4 | 75.9 | 89.9 |
| Indian corn | 10.6 | 10.3 | 5.0 | 2.2 | 70.4 | 1.5 | 7.8 | 76.5 | 85.5 |
| Oats | 10.4 | 11.4 | 4.8 | 10.8 | 59.4 | 3.2 | 10.7 | 62.3 | 67.6 |
| Rice, rough | 9.6 | 7.6 | 1.9 | 9.3 | 66.7 | 4.9 | 4.7 | 68.4 | 77.3 |
| Rye | 8.7 | 11.3 | 1.9 | 1.5 | 74.5 | 2.1 | 9.5 | 72.1 | 93.7 |
| Sorghum grain | 12.7 | 9.2 | 3.4 | 2.0 | 70.8 | 1.9 | 7.5 | 72.0 | 89.8 |
| Wheat | 10.4 | 12.5 | 2.2 | 1.8 | 71.2 | 1.9 | 9.3 | 69.8 | 91.7 |

It is sound dairy economics to feed crops grown on the farm as far as possible. The expense of hauling, middlemen's profits, etc., is thus saved and one is largely independent of fluctuating market conditions. The fertilizer value of barley is furthermore saved by this method of disposing of the crop and the danger of depleting the fertility of the land is thus decreased. For these reasons, as well as

because of the fact that barley has been shown to be an excellent dairy feed, its use in rations for dairy cows is to be recommended when its market value has not been artificially raised through a demand for the crop for other purposes than stock feeding.

* The explanation of the belief of some farmers that the feeding of barley tends to dry up milch cows is probably to be sought in the fact that such a result has frequently come when cows have been turned out on barley stubble, or fed coarse barley hay only, with no additional feed. The amount of feed they are thus able to obtain, especially on stubble pasture, is not, as a rule, likely to furnish sufficient nutriment for the maintenance of a fair dairy production, and a decrease in the milk flow naturally results, along with a gradual drying up of the cows. The barley is blamed, while it is the system of feeding that is responsible for the result observed. Milch cows producing a good mess of milk cannot be expected to pick up sufficient feed to maintain their production on barley stubble alone, but fed alfalfa hay in addition, or better still, alfalfa and some succulent feed, like silage or roots, they will give good returns for the feed that they find in the stubble field.

In view of the results and discussions presented in the preceding, there is every reason to utilize barley for feeding dairy cows when it is not needed for human food and whenever its price is not too high in comparison with other concentrates to make it an economical stock feed. During the past two seasons the insufficiency of the wheat supply has made it necessary for our people to use substitutes in bread making and for other household purposes, and barley was the most common and best known substitute available. Under normal conditions of the grain market, however, and when the attention of the civilized nations shall again be turned toward peaceful pursuits, the main market for barley in this country will again be for stock feeding, unless a demand for brewing barley should be reopened. In either case, barley growers may look to our stockmen to use a very large proportion of their crop, and it should be kept in mind that this cereal is well adapted for feeding different classes of farm animals, including dairy cattle.

* It is believed by some farmers that feeding smutty barley will tend to dry up milch cows. There is, however, no definite evidence to this effect, although the danger of feeding considerable amounts of smutty grain to any kind of stock, and especially to pregnant females, is generally recognized.

GOVT. BOTANIC GARDENS
Regd.
10-3-20.
LAL BAGH, BANGALORE.

UNIVERSITY OF CALIFORNIA PUBLICATIONS

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# I. FUMIGATION WITH LIQUID HYDROCYANIC ACID

BY
H. J. QUAYLE

# II. PHYSICAL AND CHEMICAL PROPERTIES OF LIQUID HYDROCYANIC ACID

BY
GEO. P. GRAY AND E. R. HULBIRT

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# I. FUMIGATION WITH LIQUID HYDROCYANIC ACID[1]

By H. J. QUAYLE[2]

## INTRODUCTION

Liquid hydrocyanic acid[3] was first used largely in experimental tests in 1916 and on an extensive commercial basis in 1917 for the fumigation of citrus trees in California.[4] The inauguration of this new method of fumigation has brought up a number of points on which information is needed. Among the more important of these from the standpoint of the grower and fumigator are: the killing efficiency as compared with the pot and machine methods of generation of the gas; the diffusion of the gas under the tent; effect of temperature and humidity on such diffusion; possible injury to the fruit and foliage; injury when the liquid itself comes in contact with different parts of the tree; the action of the liquid on the tents; the best methods of handling the liquid in the field; the precautions to be observed in such handling; and the cost of the liquid method as compared with other methods of fumigation. An attempt is made in the following pages to give some information on these points as based on two seasons' experience with liquid hydrocyanic acid. Other important questions related to the physical and chemical properties of the material are discussed in Part II of this bulletin.

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[1] Paper no. 58, University of California, Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.

[2] Acknowledgment is made of the assistance of Mr. A. F. Swain in 1917 and Mr. Hugh Knight in 1918 in carrying on the experiments on which this bulletin is based.

[3] Hydrocyanic acid (HCN) is a liquid, but since it has never been used until recently in this form for fumigation purposes it seems necessary, to avoid confusion, to add the superfluous word "liquid". The term for the same material which has gained common practical acceptance is "liquid gas," which appears to be still less desirable. Another name which would correctly apply is "prussic acid."

[4] Under the title "Anhydrous Liquid Hydrocyanic Acid for Fumigation Purposes," Mr. C. W. Mally published an article in the South African Journal of Science for October, 1915, giving an account of fumigation tests for the mealy bug, *Pseudococcus capensis*, on the grape. This is the first record of the use of hydrocyanic acid as a liquid for fumigation purposes that has come to our notice.

Some of the first tests with cyanide fumigation for citrus trees in 1886 involved the use of a generator outside of the tented tree.[5] This outside generator was soon discarded for earthenware pots, which were placed under each tree, and the pot method of generation was in use exclusively until the season of 1914, when the outside generator was again adopted. This portable generator,[6] however, was very different from the crude generator of 1886. It was known as the "Owl Fumigating Machine,"[7] and this generator utilized for the first time a solution of sodium cyanide. During the last two or three years the portable generator known as the "Cyanofumer", an improved machine, has been widely used. These older methods promise to be largely, if not entirely, supplanted in the near future by the use of liquid hydrocyanic acid.

## NATURE OF LIQUID HYDROCYANIC ACID AND PRECAUTIONS TO BE OBSERVED IN HANDLING IT

Liquid hydrocyanic acid has been known to chemists for many years, but probably because of its instability and its very poisonous nature, as well as the heretofore little actual need thereof, it has not been manufactured on a large scale. It is a colorless liquid, less than three-fourths the weight of water, having a specific gravity of 0.6969 at 18° C. It is also very volatile and boils at a temperature of 26.5 C or 79.7 F.[8]

Because of its very high volatility, hydrocyanic acid gas is rapidly given off from the surface of the liquid, and thus there is danger in breathing in an atmosphere close to an open container. More gas will be given off as the surface of the liquid is increased and also in higher temperatures. The greatest surface is provided, and hence there is greatest danger when the liquid is sprayed or spattered. If there is any appreciable movement of the atmosphere the operator is reasonably safe if he keeps to the windward side of the exposed liquid. In any operation giving the material an opportunity to vaporize, such as filling or emptying the machine or containers, the apparatus should

[5] Morse, F. W., The Use of Gases against Scale Insects. Bull. 71, California Agricultural Experiment Station, 1886.

[6] Gray, Geo. P., New Fumigating Machines. Monthly Bull. California State Commission of Horticulture, vol. 4, no. 2, p. 68.

[7] This machine was invented by Mr. Wm. Dingle of Los Angeles, and Mr. Dingle, together with his brother, Irwin Dingle, also deserve the credit for the inauguration, on a commercial basis, of the use of liquid hydrocyanic acid.

[8] The Cyanide Industry by Robine & Lenglen, translated by Le Clerc, p. 16, 1906.

be arranged so that it is unnecessary for the operator to hold anything in place, and thus to avoid danger. Since the vapor is inflammable, flame-lights should be kept away from near the exposed liquid.

Liquid hydrocyanic acid should be kept as cool as possible, and under ordinary circumstances this can be done by surrounding the container with cloth or sacking which is kept continuously moist. The containers should be in the shade and preferably where there is a free circulation of air. If the liquid is spilled on the hands there is no danger (if there are no cuts or abrasions) from the actual contact of the liquid, though there may be danger from the gas given off.

From our experience in the field, the most important precaution (and it would seem the most needless to mention) for operators to observe in the handling of liquid hydrocyanic acid is not to inhale in an atmosphere highly charged with the gas, and therefore to turn away when any liquid is exposed or get into the fresh air before inhaling again. For emergencies a gas mask may be a desirable part of the equipment of a fumigation crew.

## THE PLANT FOR THE MANUFACTURE OF LIQUID HYDROCYANIC ACID

The first unit of the original plant for the manufacture of liquid hydrocyanic acid in California or elsewhere, on a commercial scale, is shown in figure 1. The process is comparatively simple. All that is necessary is to subject the gas, which is generated in the usual way, to a sufficiently low temperature, when it will condense even without pressure, or only such pressure as is exerted by the gas itself in the process of generation. The plant (see fig. 2) consists essentially of generators for the generation of the gas from sodium cyanide, sulfuric acid, and water, and a condensing system where the gas is conducted into numerous flues which are bathed in cold brine from the refrigeration plant. The first product, which contains considerable water, is then distilled, which process separates most of the hydrocyanic acid from the water, yielding a product having a purity of 95 per cent or higher.

The improvement possible in the present plant is to reduce the waste in the liquefaction process in order that a greater amount may be recovered from a given amount of sodium cyanide. During the past year approximately 80 per cent of the total cyanogen has been recovered, which is equivalent to about 14.8 gallons or 86 pounds of the anhydrous liquid from a case. The total weight of anhydrous hydrocyanic acid in a case of 200 pounds of sodium cyanide (51–52

per cent cyanogen) is 108 pounds.[9] It is scarcely possible, commercially, to recover the total amount of 108 pounds from 200 pounds of sodium cyanide, although this amount will be more nearly approached as more improvements are made in the plant.

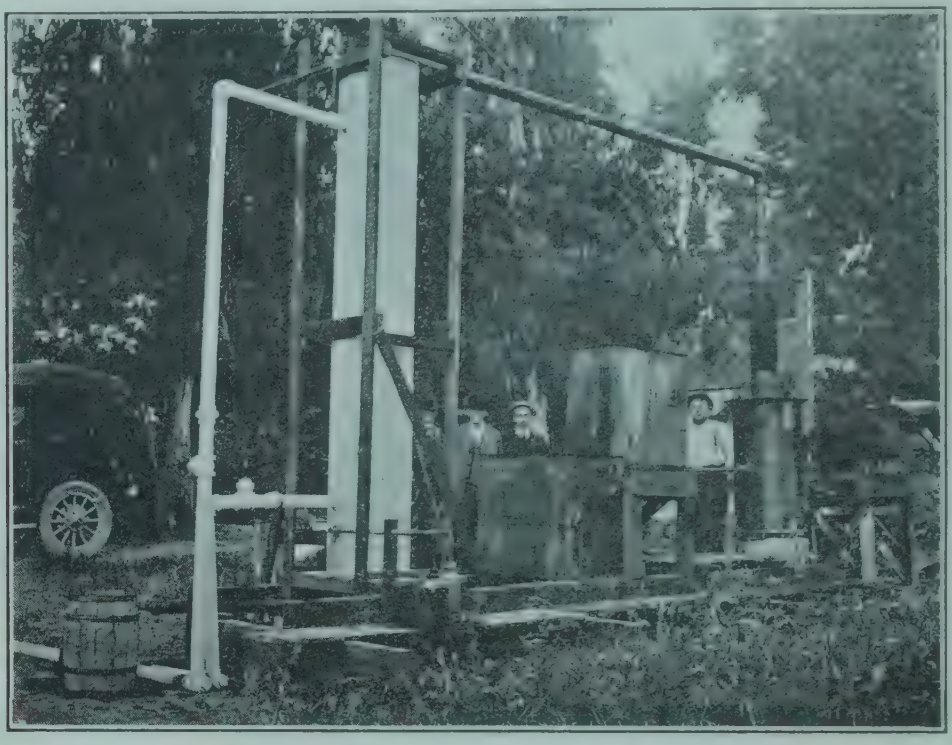

Fig. 1—First unit of original plant for the manufacture of liquid hydrocyanic acid. Azusa, California. May, 1917.

## THE ATOMIZING MACHINE

After the liquid is transported from the central plant to the field in proper containers it is placed in a machine, such as is indicated in figures 3 and 4. The atomizing machine consists of a tank holding two and one-half gallons of the liquid, a graduate for the measurement of the dosage, and a pump and spray nozzles for the atomizing of the liquid. By the upward stroke of the plunger, near the graduated scale (see fig. 4), the liquid is allowed to run into the graduate and by the downward stroke it is forced into the coil as shown. Then by the operation of the air pump on the right the liquid is forced out through nozzles at the end of the exit tube into a fine misty spray, which is immediately transformed into a gas.

[9] See Table I in Part II of this bulletin.

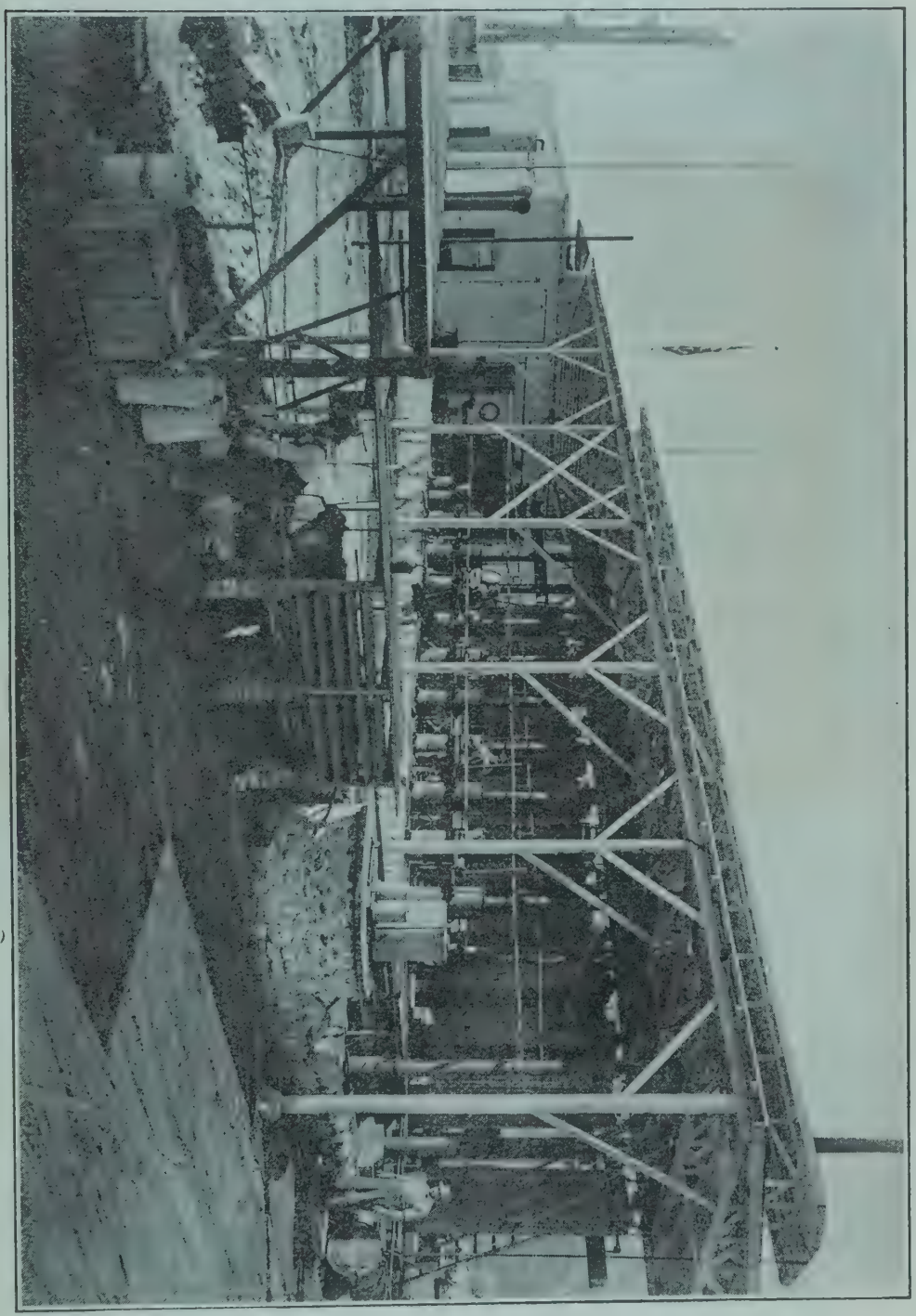

Fig. 2—Complete plant (nine units). Azusa, California. December, 1918. Refrigeration plant is shown as the white building at the left of the picture. (Owl Fumigating Co. photo.)

## GRADUATION AND OPERATION OF THE ATOMIZING MACHINE

The atomizing machine in use during the season of 1918 was graduated on the basis of the recovery of 14 gallons of liquid hydrocyanic acid from 200 pounds of cyanide; that is, the liquid recovered was made to go as far, according to our present schedules of dosage, as the original case of cyanide by other methods of generation. There are 3200 ounces in a case of sodium cyanide and 1792 fluid ounces

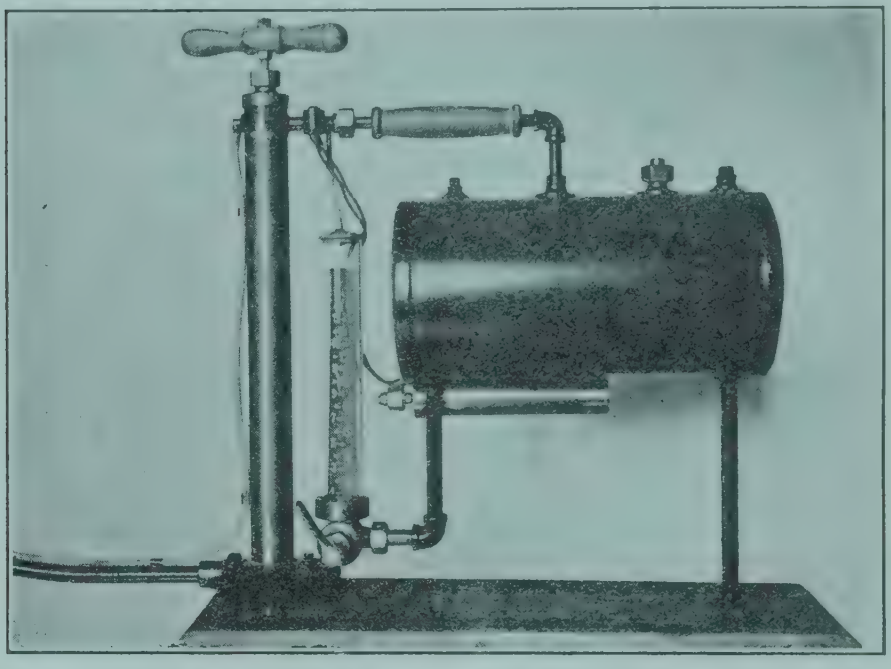

Fig. 3—Atomizing machine, in use season of 1917, for atomizing liquid hydrocyanic acid under tent.

in 14 gallons. This amount of fluid was therefore divided into 3200 parts, so that .560 fluid ounce was used as the equivalent of 1 ounce of the solid sodium cyanide. The actual amount of hydrocyanic acid in .56 fluid ounce of 95 per cent hydrocyanic acid may be calculated from the data in Table I, Part II, as follows:

Fourteen gallons of liquid of this purity weighs $5.956 \times 14 \times 16$, or 1334 ounces, but only 95 per cent of this weight is hydrocyanic acid, the remainder being impurities, mostly water. The amount of absolute hydrocyanic acid is $1334 \times .95$, or 1265.4 ounces. Dividing this by 3200, we obtain .395 as the weight in ounces of actual hydrocyanic acid in the .560 fluid ounce of liquid delivered by the atomizer as the equivalent of 1 ounce of sodium cyanide.

By other methods of generation, the pot and portable generator, we assume that about 90 per cent, at least, of the total gas is evolved.[10] Under this assumption, 1 ounce of sodium cyanide would yield a weight of .486 ounce of absolute hydrocyanic acid. If this amount were converted into a liquid containing 5 per cent of water the volume would be .693 fluid ounce.

The dosage applied by the liquid system has been only 80 per cent of that applied by the older methods. If the same dosage is to be

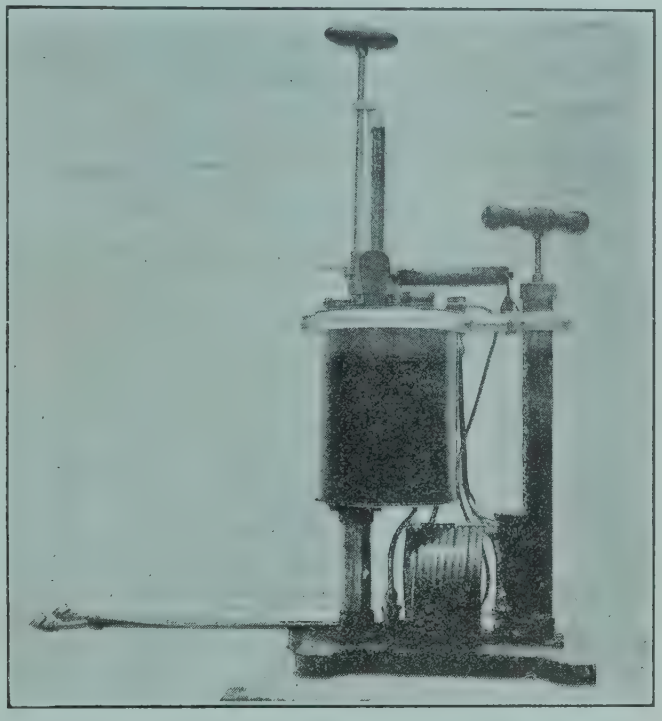

Fig. 4—Atomizing machine in use season of 1918.

applied, .693 fluid ounce of 95 per cent liquid (or .675 fluid ounce of 98 per cent liquid) must be used as the equivalent of the yield from 1 ounce of sodium cyanide when the gas is generated by the older methods.

The above figures have all been given in the American system of weights and measures. More finely graduated cylinders can be obtained, marked in cubic centimeters and fractions, and are commonly used to test the accuracy of delivery from the atomizing machine.

[10] H. D. Young, as reported in Circular 139 of the California Agricultural Experiment Station, determined that the Cyanofumer yielded, under the best working conditions, about 95 per cent of the total gas. It has usually been assumed that the yield from the pot method varied from 85 to 95 per cent. As a conservative average of both methods we have given, as above, a 90 per cent yield.

The following metric equivalents will be useful in checking up their delivery.

.693 fluid oz. = 20.5 c.c. (full dose of 95% HCN).
.675 fluid oz. = 19.9 c.c. (full dose of 98% HCN).
.560 fluid oz. = 16.5 c.c. (80% dose as applied last season).

To insure proper dosage, it is important that the atomizing machine be kept in good working order. The machine should be emptied of the hydrocyanic acid after each night's run to avoid unnecessary action of the material on the parts of the machine, and the machine allowed to remain filled with water until it is used again. The machine should be tested frequently to see that the dose, as graduated, is delivered at the end of the exit tube. This is readily done by removing the nozzles and attaching a short piece of rubber tubing to conduct the liquid into a suitably marked graduate. If, for instance, an ounce on the graduate of the machine represents 16.5 cubic centimeters, when the machine is set for a 10-ounce charge there should be 165 cubic centimeters delivered into the graduate. A convenient graduate is furnished by running a 10-ounce charge into a long, narrow bottle and marking the height of the liquid by means of a file. Water may be used in measuring the accuracy of the pump, but there may be more water actually delivered than liquid hydrocyanic acid, so that it is more accurate to use the liquid itself, in which case the proper precautions regarding safety must be kept in mind.

## EFFECT OF LIQUID HYDROCYANIC ACID ON THE FRUIT AND FOLIAGE

Gas from liquid hydrocyanic acid will injure the fruit and foliage if used in excess in much the same way as the gas generated by other methods. In many cases, however, particularly if the fumigation is done during low temperatures, the injury is often greater in the lower than in the upper half of the tree. This is accounted for under "Diffusion of the Gas."

When the liquid itself comes in contact with fruit or foliage severe burning occurs, as may be seen where the material is atomized in delivering the charge under the tent. This is not very serious, but in the case of much low-hanging fruit it is of some consequence. Such injury may be partly avoided by having a longer exit tube and adjusting the nozzles to direct the spray at a smaller angle, so as to avoid the fringe of low-hanging fruit and foliage around the outside of the tree. There is no danger if the liquid strikes the trunk, at

least of old trees. We have applied the spray directly to the trunk of two-year-old trees also without doing any injury. Possibly under conditions very unfavorable to evaporation, as during cold and wet weather, some injury might occur to the trunk of young trees.

## EFFECT OF LIQUID HYDROCYANIC ACID ON TENTS

One of the objections of the older methods of fumigation was the injury that was often done to tents. Liquid hydrocyanic acid has no effect on fabrics and there is no residue or acid anywhere around that may do such injury.

## COST OF USING LIQUID HYDROCYANIC ACID AS COMPARED WITH THE OTHER METHODS OF FUMIGATION

During the past two years there has been little difference in the cost of using the liquid as compared with the other methods of fumigation. Distance from the manufacturing plant and other factors make the cost variable. However, when the manufacture of the liquid is better stabilized the cost of fumigation should be appreciably reduced. Even if the actual material will not cost less, there will be a saving on the tents as well as less expense in handling the liquid in the field.

When sodium cyanide (51–52 per cent cyanogen) is worth thirty cents per pound, the absolute liquid hydrocyanic acid would be worth fifty-five and five-ninths cents per pound. But it is not possible, commercially, to recover 100 per cent, and, moreover, the product recovered would not have a purity of 100 per cent. Neither is the cost of liquefaction included in the above price.

If but 90 per cent is recovered in the liquid form, the corresponding price (solid cyanide at thirty cents) of the liquid would be sixty-two cents per pound. When a 90 per cent recovery contains 5 per cent water, the corresponding price per pound of the liquid would be between fifty-eight and fifty-nine cents per pound.

## DIFFUSION OF THE GAS

From previous experiments[11] it has been shown that with the gas generated by the pot or portable generator there is a greater concentration of the gas in the upper half of the tree, and consequently

[11] Quayle, H. J., Cyanide Fumigation—Diffusion of Gas Under Tent and Shape of Tree in Relation to Dosage. Jour. Economic Entomology, vol. 11, no. 3, p. 294, 1918.

better results on the scale insects in that part of the tree. With the gas which arises from the liquid under present manipulations the conditions are exactly reversed and the better results occur in the lower half of the tree. Of the three locations—top, center, and bottom of the tree—the gas from the liquid is most effective at the bottom, next at the center, and least at the top. With the pot generation there is not much difference in effectiveness between the top and center of an average sized tree, but there is a decided decrease in effectiveness at the bottom.

In field work the lower half of the tree is examined. The upper half, and particularly the top of the tree, is not examined unless some special effort is made. This fact is actually favorable to the results with the liquid and unfavorable to the results with the pots or portable generator. But there are more scales, in most cases, in the lower than in the upper half of the tree.

In 1917 an amount of liquid hydrocyanic acid equal to only 60 per cent of the total gas in a given amount of cyanide was compared with 90 per cent of the total gas from the same amount generated by the pot or portable generator. There was no difference in results by the ordinary field examination, but there was a marked difference in results by our own tests. In judging the results of the liquid as compared with other methods of fumigation in the field, therefore, allowance must be made for the necessary inaccuracy of tests under field conditions, and also for the fact that the examination is made in the lower half of the tree, where the liquid is more effective.

The manner of diffusion of hydrocyanic acid gas is different according to whether it comes from liquid hydrocyanic acid or from a generator where the cyanide, sulfuric acid, and water are combined. In the former case, vaporization takes place near the ground and the gas gradually diffuses upward; while in the latter the gas goes quickly to the top of the tree and gradually diffuses downward. This has been shown by the effects of the gas in first overcoming active insects at the bottom of the tree in one case and at the top of the tree in the other. And if the exposure is prolonged for an hour the final effect on the insects shows the same difference; that is, in the latter case more recover at the bottom and in the former case more recover at the top.

The manner of diffusion of the gas from the liquid, as explained above, is better adapted, we believe, to the killing of scales on the tree than the manner of diffusion from the pot or portable generator, particularly since most of the scales occur in the lower part of the tree, and for this reason it is possible that the liquid equivalent may

be slightly reduced. The question may properly be raised whether more scales occur in the lower half of the tree because the older methods of fumigation failed to kill them as well there, but we believe that the habits of the insects also favor that location.

## EFFECT OF TEMPERATURE ON DIFFUSION OF HYDROCYANIC ACID GAS

The question of temperature may be more vitally concerned with the diffusion of gas from the liquid than from the pot or portable generator, although it is a factor in any method of fumigation. The higher temperatures hasten the vaporization and diffusion of gas from the liquid and insure a better killing at the top of the tree. On the other hand, the higher temperatures aid in the diffusion of the gas downward with the pot method where it is first concentrated in the top of the tree. Our experiments have pointed strikingly to the tendency that the higher the temperature the more uniform is the distribution in all parts of the tree. As the temperature decreases the divergence in results increases between the top and bottom of the tree, in case of the liquid in favor of the bottom and in case of the pot in favor of the top of the tree.

In the pot or portable generator the actual gas is produced more or less regardless of the atmospheric temperature, since the different chemicals when brought in contact will act upon one another to generate the gas, during which action heat is also produced, and the warm gas readily rises. With the liquid vaporization must first occur, and low temperature, as well as high humidity, tends to retard such action. Moreover, when the gas is actually formed it is a cold gas and has a smaller tendency to rise in the tent. The atomizing of the liquid is in itself a cooling process. The bulb of a thermometer when held for a few moments before the nozzles as liquid hydrocyanic acid was being atomized showed a drop in temperature from 70° F to —4° F.

The following table gives the total average "kill" of ladybird beetles in the form "trees"[12] for the 1918 series of tests, which extended over four months and included the use of about 25,000 insects.

| | Bottom and center of tent | Top and center of tent |
|---|---|---|
| Pot | 85.7% killed | 91.1% killed |
| Liquid | 83.8% killed | 76.9% killed |

[12] The form "trees" consisted of a framework of wood in the shape of an ordinary citrus tree over which were placed ordinary fumigation tents. The dimensions were 26 × 31, thus representing fair sized trees.

From the above it will be noted that the discrepancy in efficiency with the liquid occurs in the upper half of the tree. But the experiments also showed that this discrepancy was greatly reduced with the higher temperatures. Another tendency that has been indicated is that a long exposure increases the effect of the gas from the liquid. This may be due to the slower diffusion, as well as the cooler gas from the liquid actually escaping more slowly through the tent. By the other methods of fumigation it is quite well established that there is no value in increasing the time of exposure beyond about forty-five minutes.

As to whether the tendency of the gas from the liquid to remain largely in the lower half of the tree during low temperatures is a serious objection to its practical use, or whether it is practicable to increase the exposure, remains for further experience to determine. Heating the gas, or a better system of atomizing, or gasifying the liquid, are two possible ways of overcoming the poor diffusion, although this might complicate the field manipulations.

## THE EFFICIENCY OF LIQUID HYDROCYANIC ACID AS COMPARED WITH POT AND MACHINE GENERATION

The killing efficiency of the liquid as compared with other methods of fumigation was determined: (*a*) by comparative tests in a fumatorium; (*b*) by comparative tests under form trees; (*c*) by comparative tests in the field; and (*d*) by examination of commercial work in the field.

In addition to the scale insects of citrus trees, for which pests fumigation work is carried on, ladybird beetles were used as an index of the results. Our two seasons' work with the beetles lead us to conclude that they are more desirable than scale insects as furnishing a sharp index of comparative fumigation results. In the case of scale insects, there may be 100 per cent killed with ordinary dosages, where these dosages vary as much as 25 per cent. With the highest dosage that may be used with safety to the citrus trees, some of the beetles will survive, and increasing numbers will survive as the dose is decreased. It is possible also to determine the difference in results between the top and bottom of a tree, with the beetles properly placed, while with the scale insects occurring naturally on the tree it is more difficult to make such a distinction. All of our results, however, are based on work both with the beetles and the scale insects.

During the season of 1917, in our tests both in the field and under form trees, the results with the liquid were less satisfactory than the results carried on at the same time with the pot and cyanofumer.

This may be accounted for from the fact that during that season the liquid was not of high purity until late in the season, and also because the machine in use that year was graduated on the recovery of only 12½ gallons of liquid from a case of cyanide. In our examination of commercial fumigation, however, there was little if any difference that could be determined by the results on the scales in the field.

During the season of 1918 our own tests again showed that the liquid was slightly less efficient than the pot method, although there was a marked improvement over the preceding year. In the field, as in 1917, no appreciable difference could be distinguished. Tests carried on with the cyanofumer and liquid on alternate trees in the same tent-throw, thus insuring similar conditions, failed to distinguish any difference either on beetles which were placed in the tree or on the scales on the fruit and foliage. The results thus determined, however, represent the effect on the insects within six or eight feet of the ground, which fact is important as discussed under the head of "Diffusion of the Gas."

In our experiments with form "trees" the difference between the pot and liquid methods was brought out by considering the effect of the gas at three different points, namely, one foot from the top, one foot from the bottom, and in the center of the tree. When the results in the lower half only were considered, there was no important difference between the pot and liquid methods. But when the results on the upper part of the tree were included, they were more favorable to the pot method.

While, so far as field conditions and examination go within seven or eight feet of the ground, between the liquid and the older methods of fumigation the results have shown little important difference, we believe that a greater recovery of liquid from a given amount of cyanide is necessary, and that it is desirable to increase the amount given to the tree over that of the past two years. Judging from the field work, we had come to believe that when temperature conditions are favorable the gas from the liquid must be 10 to 15 per cent more effective than the same amount of gas from the pot or portable generator. Fourteen gallons of liquid hydrocyanic acid of 96 or 98 per cent purity recovered from 200 pounds of sodium cyanide represent only 75 per cent of the total available gas, while by the other methods 90 per cent of the total gas in 200 pounds was recovered, making a difference of 15 per cent. Yet, during the past year, the 14 gallons of liquid was made to cover the same ground as 200 pounds of sodium cyanide generated by the other methods. When the results in all parts of the tree are considered, however, as shown by our

comparative tests for two seasons, we believe that, under normal conditions, practically the equivalent in the actual amount of gas must be used to effect the same results regardless of whether the source of the gas is from liquid hydrocyanic acid or from the pot or portable generator. Consequently 90 per cent at least, representing 17 gallons or 100 pounds of liquid hydrocyanic of 96 or 97 per cent purity, should be recovered from 200 pounds of sodium cyanide, and this amount should be made to cover the same ground as 200 pounds of sodium cyanide on the basis of the dosage schedules now in use. This would be equivalent to using approximately 20 cubic centimeters to correspond to one ounce of sodium cyanide (51–52 per cent cyanogen). (See discussion under "Graduation and Operation of Atomizing Machines," p. 398 and table 1, p. 412.)

## SUMMARY AND CONCLUSIONS

Liquid hydrocyanic acid, a new means of citrus fumigation, first used on a commercial basis in 1917, has rapidly come into favor.

The place where the greatest concentration of gas occurs under the tent from the liquid is practically the reverse of that from the pot or portable generator.

With the former method the most effective killing is at the bottom of the tree, while with the latter the most effective killing is at the top.

Aside from the scale insects, more than 75,000 ladybird beetles have been used in our comparative tests as an index of results.

The use of these insects has given discriminating data concerning the diffusion of gas under the tent, as well as on the efficiency of the different methods of fumigation, and these data have been verified by extensive field tests.

The greatest possible yield is 108 pounds or 18.56 gallons of anhydrous liquid hydrocyanic acid from 200 pounds of sodium cyanide (51–52 per cent cyanogen).

The amount of liquid hydrocyanic acid (95–98 per cent) that has been recovered at the plant during the past year has been about 78 per cent of the total available.

The amount of gas evolved by the pot or portable generator is estimated at 90 per cent of the total available gas.

During the past year 75 per cent of the gas from a given amount of cyanide in the liquid form was made to cover the same ground as 90 per cent from the same amount by the ordinary methods of generation.

Thus, while there has been a discrepancy of 10 or 15 per cent in the actual amount of gas used through the liquid method, the results in the field have not indicated any important difference on the scale insects.

Our own tests, however, both in the field and laboratory, have indicated about such difference as would be expected.

This apparent discrepancy between our own tests and commercial work in the field may be accounted for through the great variability in field work and by the difference, as has been determined, in the diffusion of the gas from the different methods.

Field examinations are usually limited to an examination of the scales within six or eight feet of the ground.

Our own tests have included the top of the tree as well. From these tests, when the results at the center and the bottom only were considered, there was practically no difference between the liquid and the pot, which harmonizes with the results in the field.

When the results at the center and top only were considered, the pot method was more efficient than the liquid method.

When the results in all parts of the tree are considered, it is necessary to use about 20 cubic centimeters of liquid hydrocyanic acid (96 or 98 per cent) to equal one ounce of sodium cyanide as given in the schedules of dosage now in practical use.

Units representing 20 cubic centimeters may therefore be substituted for the ounces, and the atomizing machines should be graduated to deliver 20 cubic centimeters for each ounce called for in the schedules.

# II. PHYSICAL AND CHEMICAL PROPERTIES OF LIQUID HYDROCYANIC ACID

By GEO. P. GRAY and E. R. HULBIRT[1]

The ready acceptance of liquid hydrocyanic acid by fumigators during the first year of its commercial production strongly emphasized the need of a better knowledge of the physical and chemical properties of a liquid of such unusual characteristics. The Fruit Growers' Supply Company, the purchasing organization of the California Fruit Growers' Exchange, were much concerned over the scarcity of information regarding the liquid being marketed, and financed an investigation of the plant and product of the Owl Fumigating Company at Azusa, California, during the month of August, 1918. This preliminary investigation not only proved to be of much value to the growers but also disclosed such a variety of questions to be answered that a co-operative arrangement for the continuation of the investigation was made between the supply company and this laboratory. The following pages constitute a report of these investigations.[2]

## COMMERCIAL CONSIDERATIONS

The questions of most immediate concern appeared to be of a commercial nature. The liquid being delivered to consumers was not sold outright, but was delivered upon an exchange basis. The fumigators purchased their own sodium cyanide and brought it to the plant

[1] Co-operating chemist, representing the Fruit Growers' Supply Company.

[2] The writers wish to express their appreciation of the attitude of Messrs. Ervin and William Dingle, who have extended to them every courtesy during the course of the investigation and have given them the freedom of their plant, and have done everything in their power to facilitate the work. The Board of Trustees and Professor F. S. Hayden, Principal of the Citrus Union High School, have generously allowed the free use of their laboratories and apparatus. This accommodation has greatly facilitated the investigation by allowing the testing laboratory and the liquifying plant to be located in close proximity. The interest shown by Mr. R. S. Woglum and Mr. H. D. Young of the United States Bureau of Entomology in developing methods of analysis and in the test runs of the plant has been of great assistance. Mr. F. W. Braun, Mr. M. B. Pattison, and Mr. J. D. Neuls of the Braun Corporation have offered many suggestions, particularly concerning methods of analysis. The many accommodations and courtesies extended by Mr. C. C. Hillis, Mr. C. A. Savage, and other officials of the Azusa-Covina-Glendora Fruit Exchange are much appreciated.

for treatment. The plant furnished the sulfuric acid, generated, and liquefied the hydrocyanic acid at a fixed charge per case of sodium cyanide. There appeared to be no well established idea as to what quantity of liquid should be recovered from a case of sodium cyanide under the operating conditions of the plant, though it was generally conceded that the quality of the liquid being delivered to the consumer was of good grade.

*Test Runs.*—In order to determine the amount and quality of liquid recovered from a case of sodium cyanide under the operating conditions of the plant, the owners offered to make a test run to be carried on under the supervision of a representative of the Fruit Growers' Supply Company. The results of these tests were to be used as a basis of settlement between fumigator and plant. In order that the results should be above criticism of partiality, the following gentlemen kindly accepted an invitation to be present to witness the test run: Messrs. R. S. Woglum, entomologist, and H. D. Young, chemist, representing the U. S. Bureau of Entomology; Professor H. J. Quayle, entomologist, representing the Citrus Experiment Station of the University of California; Mr. W. C. Bass, chemist, representing the Owl Fumigating Company; and the senior writer, representing the Fruit Growers' Supply Company, and unofficially the Insecticide and Fungicide Laboratory of the University of California. The proposed procedure of the test was outlined and agreed upon by the representatives present as being a fair one. Seventeen cases of sodium cyanide (3400 pounds) were weighed out and sampled for the test run. The plant was operated in the usual manner and the yield of liquid was weighed and sampled. The samples noted above were independently analyzed by Messrs. Young, Bass, and Gray. On comparing the results of analysis it was found that the three sets of results were in essential agreement. Not being willing to base conclusions upon a single run of the plant, another test was made a week later in a similar manner. The liquid hydrocyanic acid recovered in the first test run was 80.1 per cent of the greatest possible yield; in the second, 76.3 per cent; an average of 78.2 per cent. The average purity of the liquid obtained in the first run was 97.57 per cent; in the second, 94.27 per cent.

While the yield of 78 per cent was quite disappointing, it must be recognized that this is an infant industry, and that with increasing knowledge and experience with the liquid continual improvement in all phases of its manufacture and use may be expected. The constructors of the plant had no previous work to guide them in selection of their equipment. There were certain evident losses in the operation

of the plant which will doubtless be remedied before next season. It also appears that there are certain other losses, the causes of which are somewhat obscure.

*Quality of Liquid.*—Frequent analyses and tests have been made of the liquid being delivered to consumers, covering a period from the first of August to the close of the fumigating season. The average purity of the liquid delivered to consumers has been above 95 per cent absolute hydrocyanic acid. Occasional drums of liquid have been noted which were considerably below this figure. After the plant was supplied with hydrometers so that the purity of the output could be quickly approximated, the delivery of a low-grade drum of liquid was rare. Liquid testing considerably below 95 per cent was returned to the crude liquid storage tank and redistilled.

The writers are as yet undecided as to the comparative merits of a liquid testing, say, 95 per cent and one testing, say, 98 per cent or more. It is even maintained by some fumigators that the high percentage of liquid is too volatile for safe handling, and that they much prefer a liquid testing 95 to 96 per cent. The definite determination of this point must be made by future investigation. In the present state of our knowledge, it is believed that a material testing 95 per cent or more of hydrocyanic acid is of a satisfactory grade. The plant as operating at present is quite capable of and does produce liquid of this quality, or better, many samples testing over 98 per cent.

*Return Per Case.*—As the plant was operated during the past season and based upon the investigation reported above, the following is believed to be a fair return per case of two hundred pounds of sodium cyanide, testing 96–98 per cent of sodium cyanide:

1. A minimum of 85 pounds of absolute hydrocyanic acid; or
2. A minimum of 90 pounds of liquid testing not less than 95 per cent hydrocyanic acid.

Liquid of 95 per cent purity should not test less than 66° on the Baumé hydrometer at a temperature of 60° Fahrenheit, corresponding to a specific gravity of .715. A gallon of liquid of this density would weigh 5.956 pounds.

The above must not be taken as final. As the necessary information is accumulated it is confidently anticipated that the yield in the future will be equal to or even greater than that now obtained from the portable generators in common use.

*Weight Basis.*—Settlements are now made on a basis of gallons of liquid returned per case of sodium cyanide delivered. The liquid can be fairly easily measured when delivered to the consumer by an automatic measuring device, but measuring of so volatile and poisonous

a liquid without such a device is a rather dangerous undertaking and is not so easily subject to accuracy as weighing. It is strongly urged that the weight basis be adopted in transactions dealing with liquid hydrocyanic acid. The strongest argument in its favor is that the consumer would have a ready and convenient means of checking up deliveries. The weight of the empty drum could be determined and the figures painted on the drum. The weighing of the full drum only requires a short time, and in that way the weight of the liquid delivered would be determined by deducting the weight of the container from the gross weight. An additional argument in favor of the adoption of the weight basis in commercial transactions is evident from the following: The weight of the recovered liquid will be the same at any temperature. The corresponding number of gallons, however, will vary according to the temperature of the liquid.

It has been held by some that the weight basis would place the consumer at a disadvantage for the reason that a low-grade liquid weighs considerably more than a high grade. It is not to be expected that a commercial product could be absolutely uniform. If, however, 95, 96, or some other percentage were finally adopted as the minimum standard of purity, the consumer would be justified in refusing any material of less purity than this. Fortunately it is unnecessary to have a chemical analysis made to determine purity. This can be determined accurately by observing specific gravity and temperature and using the appended reference tables.

Table I following will be of use in making settlements for the return of liquid, in making dosage calculations, etc. The figures in the table showing yield in gallons are correct when the liquid is measured at a temperature of 15° C (60° F) only.

## TABLE I

WEIGHTS AND VOLUMES OF VARIOUS GRADES OF COMMERCIAL LIQUID HYDROCYANIC ACID CORRESPONDING TO VARIOUS PERCENTAGES OF THE MAXIMUM YIELD FROM ONE CASE (200 LBS.) OF SODIUM CYANIDE, CONTAINING 52% CYANOGEN

The figures in column 3 have been calculated from our own experimental data and using the value of 8.329 (8.32892) pounds as the weight in air of 1 gallon of water at 15° C (Circ. 19, U. S. Bureau of Standards). These were found by multiplying 8.329 by the specific gravity of the corresponding liquid.

| Quality of product | | Weight of 1 gal. at 15° C (60° F) | Liquid Hydrocyanic Acid Recovered | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 100% | | 95% | | 90% | | 85% | | 80% | |
| | | | Weight and Volume of Various Grades | | | | | | | | | |
| Grade | % HCN | lbs. | lbs. | gals. | lbs. | gals. | lbs. | gals. | lbs. | gals. | lbs. | gals. |
| High | 100 | 5.818 | 108.0 | 18.56 | 102.6 | 17.63 | 97.2 | 16.71 | 91.8 | 15.78 | 86.4 | 14.85 |
| High | 99 | 5.845 | 109.1 | 18.66 | 103.6 | 17.72 | 98.2 | 16.81 | 92.7 | 15.86 | 87.3 | 14.94 |
| High | 98 | 5.873 | 110.2 | 18.76 | 104.7 | 17.83 | 99.2 | 16.89 | 93.7 | 15.95 | 88.1 | 15.01 |
| Satisfactory | 97 | 5.901 | 111.3 | 18.86 | 105.8 | 17.93 | 100.2 | 16.98 | 94.6 | 16.03 | 89.01 | 15.10 |
| Satisfactory | 96 | 5.928 | 112.5 | 18.98 | 106.9 | 18.03 | 101.2 | 17.07 | 95.6 | 16.13 | 90.0 | 15.18 |
| Satisfactory | 95 | 5.956 | 113.6 | 19.07 | 108.0 | 18.13 | 102.3 | 17.18 | 96.6 | 16.22 | 90.9 | 15.26 |
| Low | 94 | 5.984 | 114.9 | 19.20 | 109.1 | 18.23 | 103.4 | 17.28 | 97.7 | 16.33 | 91.9 | 15.36 |
| Low | 93 | 6.012 | 116.1 | 19.31 | 110.3 | 18.35 | 104.5 | 17.38 | 98.7 | 16.42 | 92.9 | 15.45 |
| Low | 92 | 6.040 | 117.3 | 19.42 | 111.5 | 18.46 | 105.6 | 17.48 | 99.8 | 16.52 | 93.9 | 15.55 |
| Low | 91 | 6.068 | 118.7 | 19.56 | 112.7 | 18.57 | 106.8 | 17.60 | 100.9 | 16.63 | 94.9 | 15.64 |
| Low | 90 | 6.097 | 120.0 | 19.68 | 114.0 | 18.70 | 108.0 | 17.71 | 102.0 | 16.73 | 96.0 | 15.75 |

## PHYSICAL PROPERTIES

*Miscibility.*—During the earlier stages of the commercial production of the liquid it was erroneously believed that mixtures of hydrocyanic acid and water would separate on standing into layers of different composition. The reason for this belief was that the first run in the morning was often diluted with water remaining in the condensors and conveying pipes after flushing at the end of the previous day's run. As soon as this point was established it became the custom at the plant to draw off the first run of low-grade liquid and return it to the crude liquid receiver to be redistilled.

It has been determined that hydrocyanic acid is miscible with water in all proportions. When once thoroughly mixed, the liquid remains homogeneous throughout, except as affected by chemical decomposition. When the two are mixed there is always an appreciable contraction in volume accompanied by a fall in temperature. This fact complicated the problem of determining the relation of percentage purity to specific gravity and necessitated extensive experimentation, as will be described under a later heading.

*Evaporation.*—The anhydrous liquid has a very strong affinity for water, so if a high-grade liquid is exposed to moist air it will either absorb moisture from the air and become dilute or, the acid being more volatile than water, will evaporate at a greater rate, leaving a residue of low-grade liquid.

A cylinder was filled with a much diluted and thoroughly mixed sample of hydrocyanic acid. This was analyzed and then the cylinder was allowed to stand uncovered in an exposed place for fifteen hours, so that evaporation might proceed readily. In that time about 30 per cent of the liquid had evaporated. A sample of the remaining liquid was then analyzed, and the results were as follows:

Sample from cylinder at first: 46.6% hydrocyanic acid.
Sample from cylinder after evaporation: 29.4% hydrocyanic acid.

A high-grade liquid evaporates so rapidly that its temperature is lowered at times even to the point where particles of ice are formed. In experimenting with the liquid in a room where the temperature was about 90° F, and in a good current of air, a cylinder was filled with the liquid and enough more added so as to run down the sides of the cylinder. The temperature of the liquid was reduced ten degrees in ten minutes. This is a very desirable property, for if the liquid is warmed up to near the boiling point and allowed to evaporate freely it is automatically cooled and evaporation thus retarded.

*Vapor pressure* has an important bearing on the strength of materials required for containers. Apparently the vapor pressure of hydrocyanic acid is very small. In other words, a comparatively slight pressure is required to retain the substance in a liquid state, even at temperatures near its boiling point. The writers have as yet been unable to investigate this matter, but the figures shown in Table II are contributed through the courtesy of Mr. W. C. Bass of Los Angeles as being approximately correct.

TABLE II

PRESSURE OF HYDROCYANIC ACID (ABOUT 97% HCN) IN A CLOSED CONTAINER AT DIFFERENT TEMPERATURES

| Temp. deg. F | Pounds per sq. in. |
|---|---|
| 87 | 3.4 |
| 94 | 4.9 |
| 100 | 7.9 |
| 105 | 9.8 |
| 110 | 11.8 |
| 115 | 13.3 |
| 120 | 15.7 |
| 125 | 17.7 |

## SPECIFIC GRAVITY

It is important for the fumigator to know the approximate percentage of hydrocyanic acid in the liquid which he uses in order to enable him to reject material of low grade. This is of special importance if the weight basis be adopted in making settlement. The sampling and analyzing of a poisonous and volatile material of this sort presents unusual difficulties. Inasmuch as the density of the pure liquid is less than three-fourths that of water and the principal impurities which are apt to be encountered in a commercial liquid are water or other impurities which are heavier than the pure liquid, it was early recognized that the determination of specific gravity might be utilized in approximating the percentage purity of a commercial liquid. This view was confirmed by preliminary experiments and a hydrometer spindle has been used throughout the course of these investigations as a ready and satisfactory means of approximating purity of the output of the plant.

The specific gravity of the liquid materially changes with varying temperatures. Also on account of the contraction in volume when

water and acid are mixed the rate of variation varies according to the percentage of water and acid in the sample. These complications, however, do not interfere with the application of this method of approximation, provided the extent of these variations are known.

This matter was gone into very thoroughly and data have been obtained giving complete information on all of the points involved. These data, presented in the reference tables at the end of this bulletin, were determined by means of a hydrometer spindle accurate to the third decimal place. The temperature was observed in degrees of the Centigrade scale. Table VI will indicate the percentage of absolute hydrocyanic acid corresponding to various densities and at a range of temperature from 5° to 22° C. Hydrometer spindles graduated in specific gravity are not as readily obtainable as spindles reading in degrees Baumé. In order to make the tables available for use with a Baumé hydrometer, they have all been recalculated, indicating the corresponding Baumé reading and the variation in temperature according to the Fahrenheit thermometer. These data are given in Table VII.

These determinations were all made upon the commercial liquid. The specific gravity at different temperatures of 100 per cent material, however, has been calculated from the data for liquids of lower percentages. It is interesting to note that the calculated specific gravity at 18° C of 100 per cent acid is .6943. The commonly accepted specific gravity of this material is .6967.[3] The close agreement of these two figures is believed to be a confirmation of the accuracy of the determinations.

Thirteen samples of liquid hydrocyanic acid were selected, being representative samples of the product of the liquefying plant over a period of three months. Some were intentionally diluted with water. The temperature of the samples was made to vary and conditions so arranged that they would afford a fair measure of the accuracy of the tables. The specific gravity and temperature of each were carefully observed and the percentage of hydrocyanic acid determined by reference to the tables, and then by careful analysis. The results are shown in Table III. The laboratory analysis is accurate to two-tents of 1 per cent. Since there is no greater variation than the experimental error between the percentages determined by analysis and by the tables and since the conditions of the samples were made quite variable, the following table is considered to be a positive justification of the tables and confirmation of their accuracy.

[3] H. E. Williams, Chemistry of Cyanogen Compounds, and their Manufacture and Estimation. J. and A. Churchill, London, 1915.

TABLE III

COMPARISON OF RESULTS OBTAINED ON DETERMINATION OF HCN BY USING OUR REFERENCE TABLES AND BY ANALYSIS

| Observed specific gravity | Temperature deg. C | HCN by tables % | HCN by analysis % |
|---|---|---|---|
| .736 | 17 | 88.2 | 88.2 |
| .7115 | 16 | 95.6 | 95.6 |
| .704 | 16.5 | 97.7 | 97.8 |
| .7045 | 16 | 97.8 | 97.9 |
| .705 | 16 | 97.7 | 97.7 |
| .704 | 16 | 97.9 | 98.1 |
| .715 | 16.5 | 94.5 | 94.7 |
| .716 | 16 | 94.4 | 94.6 |
| .720 | 5.25 | 97.7 | 97.7 |
| .713 | 10 | 97.7 | 97.7 |
| .7405 | 13.5 | 88.1 | 88.2 |
| .742 | 12 | 88.2 | 88.2 |
| .7185 | 14 | 94.5 | 94.7 |

*Use of the Tables.*—The tables referred to above make it possible to determine the quality of the liquid in a moment's time by the use of a hydrometer spindle graduated either in specific gravity or Baumé degrees, taking into account the temperature of the liquid. Many of these spindles are provided with a thermometer, so that both observations can be made from one instrument. It requires no technical skill to make such observations. Any one without previous experience can easily read the hydrometer accurately within one degree Baumé. This introduces an error of approximately 1 per cent. With a little practice and with an accurately graduated instrument an even closer approximation than this can be made. After the hydrometer reading and the temperature of the liquid have been taken, the corresponding percentage is determined by referring to Table VI if the spindle reads in specific gravity or to Table VII if the Baumé hydrometer has been used.

*The Cyanometer.*—The accumulation of the data referred to above has made possible the construction of a hydrometer graduated directly in percentage hydrocyanic acid. The idea of such an instrument is not a new one. In fact, alcoholometers, salometers, saccharometers, etc., are in common factory use for the determination of alcohol in mixtures of alcohol and water, salt in brine, and sugar in syrup respectively. Our data have made possible the construction of a "cyanometer" to be used for a purpose similar to the above. It is possible that the somewhat restricted use for these instruments might not make their construction attractive to instrument makers. In this case the reference tables are available. If, however, the idea appeals

to the fumigators as of sufficient importance and the demand is great enough, an instrument could be procured which will indicate percentages of hydrocyanic acid directly. This, of course, should be provided with a thermometer and with a table of temperature corrections. All of these data could easily be contained within the glass shell of the average hydrometer. A simplified scale for the graduation of this instrument as well as a table for temperature correction is shown below.

TABLE IV

DATA FOR CONSTRUCTION OF THE CYANOMETER

| Marked on scale | Corresponding marks on hydrometers | | Temperature corrections | |
|---|---|---|---|---|
| HCN% at 60° F | Baumé reading at 60° F | Specific gravity equivalent to Baumé | deg. F | Corections |
| 100 | 71.0 | .697 | 70 | −2% |
| 99 | 69.8 | .701 | 65 | −1% |
| 98 | 68.7 | .705 | 60 | 0 |
| 97 | 67.8 | .708 | 55 | +1% |
| 96 | 66.9 | .711 | 50 | +2% |
| 95 | 65.9 | .715 | 45 | +3% |
| 94 | 65.0 | .718 | 40 | +4% |
| 93 | 64.1 | .721 | | |
| 92 | 63.2 | .725 | | |
| 91 | 62.3 | .728 | | |
| 90 | 61.4 | .732 | | |
| 89 | 60.6 | .735 | | |
| 88 | 59.7 | .738 | | |
| 87 | 58.8 | .742 | | |
| 86 | 58.0 | .745 | | |
| 85 | 57.1 | .748 | | |

An instrument of this kind is commonly calibrated for use at a temperature of 60° F, and is correct at that temperature only. If used at any other temperature than the above the observed reading should be corrected according to the variation above or below the temperature at which the instrument is calibrated.

## CHEMICAL PROPERTIES

### *Hydrocyanic Acid; Prussic Acid*

Chemical Symbol, HCN; Molecular Weight, 27.02

### DECOMPOSITION

Most impurities tend to accelerate the decomposition of hydrocyanic acid. The purer the liquid is the better its keeping qualities. Impurities may be present especially from contact with metals or in

the form of other products. These may have their origin in the manufacturing plant or in the containers used for handling and dispensing the liquid. Some metals react with the liquid and the metallic cyanides thus formed may later be precipitated, forming a troublesome sediment. In some cases they can be easily removed by straining. Some of the causes of decomposition are solely under the control of the manufacturer, while others are under the control of the fumigator.

When the liquid decomposes it forms several substances which themselves accelerate decomposition of fresh liquid with which they come in contact. In other words, decomposition appears to be a cumulative process. Undesirable impurities may be imperceptible in a freshly prepared liquid, but nevertheless have their effect. The decomposition is gradual at first and is marked with the appearance of a faint yellow tint and an accompanying lowering of percentage of hydrocyanic acid. As this proceeds the color becomes deeper and merges into brown, when the chemical changes take place more rapidly and new gases are formed in great quantity. At this stage a dark brown or black flaky precipitate is formed. After complete decomposition the newly formed gases have escaped, leaving a bulky, black sediment much resembling carbon, or, if the liquid is confined, the pressure of these gases is oftentimes sufficient to burst the container. The above description is well illustrated by the following record of a decomposed sample, Table V.

TABLE V

RECORD OF A DECOMPOSED SAMPLE

| Analysis | Date, 1918 | Color of sample | Weather | % HCN |
|---|---|---|---|---|
| 1 | Oct. | Straw color | warm | 94.7 |
| 2 | 4 | Amber | warm | 93.8 |
| 3 | 8 | Amber | warm | 93.2 |
| 4 | 14 | Amber | cool | 93.2 |
| 5 | 16 | Amber | cool | 93.3 |
| 6 | 21 | Yellow | cool | 92.8 |
| 7 | 25 | Yellower | cool | 92.3 |
| 8 | 29 | Very yellow | cool | 92.3 |
| 9 | Nov. 2 | Brownish yellow | warm | 90.2 |
| 10 | 4 | Black sludge | cool | 80.0 |

*Warning Signs.*—So far as observed, when a sample starts to deteriorate a color of some sort, usually yellow, is always formed. Ammonia seems to be one of the gases formed in greatest quantity, or at least one which can most readily be detected in decomposing hydrocyanic acid. The formation of any color or an odor of ammonia then may be taken as a warning.

*Keeping Qualities.*—The question has often been asked, how long the liquid will keep. This question cannot be answered easily. Some samples several years old are apparently as good now as when first prepared. Other samples decomposed completely within a few days or weeks. One apparently good sample which was closely observed completely decomposed in forty days. Another sample of similar appearance and kept under the same conditions was as good at the end of four months as it was at first. The natural life of the liquid depends upon its history in the course of manufacture as well as upon the conditions of handling and storage. Some of the factors influencing the keeping qualities of the liquid are discussed below.

*Dilution.*—Our experiments point toward the conclusion that the presence of water, especially in amounts more than 5 per cent, are favorable to decomposition and tend to increase the effect of the acid upon many metals. It is probable that a liquid as nearly anhydrous as could be produced would be the most desirable from these standpoints. The great volatility of a liquid of this nature, however, may necessitate a compromise between the highest purity obtainable and one more convenient to handle.

*Temperature.*—The liquid resists decomposition much better at low temperatures, other conditions being the same, than it does at high temperatures. If held in an open container it would boil at a temperature of about 80° F. The liquid should be kept cool at all times, preferably never becoming warmer than 60° F. If the liquid is allowed to become sufficiently warm, it is very easy to see that a closed drum of liquid could be burst (see Table II). Some of the explosions of previous years may be partly accounted for from this cause, as well as from the decomposition of the liquid producing gases of greater vapor pressure than hydrocyanic acid.

*Decomposition Residue.*—The dark colored deposit from a partly decomposed sample has been demonstrated to be highly favorable to decomposition when placed in a fresh sample. This matter has an important bearing on the washing out of delivery containers, atomizing machinery and any other vessels used in storage or handling. Investigations are under way in an effort to disclose some substance which can be used to change the nature of this deposit so that it would not be so favorable to decomposition. Sufficient progress has not been made to warrant publication.

A portion of the black solid residue remaining after a sample of hydrocyanic acid had completely decomposed was spread out and left exposed to the air for three weeks. At the end of that time some of this solid, resembling charcoal in appearance, was added to some hydro-

cyanic acid in a small flask and set away. The liquid became slightly yellow as soon as the material had settled. Within one day the liquid was brownish yellow; in four days, brown and throwing down a deposit; within two weeks, the liquid had completely decomposed. The same lot of liquid without the addition of decomposition residue remained unimpaired for several months.

Some of the black deposit being thrown down from a decomposing sample was filtered from the liquid and added to a fresh portion of clear liquid and then set away. The effect was in all respects the same as described above, except that the chemical action was considerably slower. In four days the liquid had become bright lemon yellow; in two weeks, brown; and in five weeks had completely decomposed.

*Alkalies.*—It has been long known that alkalies are favorable to decomposition. This has been confirmed in our investigations using sodium, potassium, and ammonium hydroxides. Ammonia was found to be the most energetic.

*Acids.*—Sulfuric acid and hydrochloric acid even when used in large amounts do not appear to affect the liquid seriously. Nitric acid, however, has a very serious influence.

*Sodium Cyanide.*—The undesirable effect of sodium cyanide is equal to or even greater than the alkalies mentioned above.

*Soap.*—Several varieties of soap were found to decompose the liquid very rapidly. Doubtless this is due to the presence of alkali or to hydrolysis of alkali salts.

*Packing Materials.*—Quite a variety of the more common packing materials—pure rubber, red rubber, white rubber, leather, "garlock", an asbestos packing, and an asphalt canvas packing—were experimented with. So far as we were able to observe, there is nothing dangerous about any of these ordinary materials used for packing so far as the decomposing effect on hydrocyanic acid is concerned. Rubber does not appear to affect the liquid, but the rubber itself is sooner or later destroyed.

*Metals.*—Some metals are attacked by the acid. On the other hand, some metals seem to act as catalytic agents and promote a rapid decomposition of the acid. Others apparently have no effect whatever. The metals appearing to act upon the acid more energetically are: *lead, commercial tin, solder, cast iron,* and *steel.* These metals very clearly should be avoided in the construction of liquefying plants and in delivery containers, atomizing machinery, fittings, etc.

## ACTION ON METALS

A series of experiments was made to test the action of liquid hydrocyanic acid on various metals, the object being to obtain data for the intelligent selection of materials for the construction of delivery containers, atomizing apparatus, condensers and other equipment for use in connection with the new industry.

Small pieces of various metals, solid and plated, were first weighed and then sealed in glass tubes containing a small quantity of liquid hydrocyanic acid. The amount of liquid was regulated so that only a part of the metals was exposed to the liquid while the remainder was exposed to the vapors. These specimens have been under observation for four months and would all have furnished fairly complete data on the action of the acid on the commoner metallic substances except for the recent suspicion that the glass itself may have been responsible for the decomposition of the liquid.

Our experiments have shown that certain kinds of *glass* under some conditions appear to cause the decomposition of liquid hydrocyanic acid. So far as we are able to determine, boro-silicate glass does not affect the liquid. The experiments are therefore being repeated, using this kind of glassware for the test containers. A large variety of metals and various enamels and varnishes are also being tested. The complete results of these experiments, however, will not be available for the coming fumigating season.

*Resistant Metals.*—Notwithstanding the possible combined influence of metal and glass upon liquid hydrocyanic acid, a few metals have not been affected by four months' contact with prussic acid. *Aluminum, block tin,* and *pure zinc* apparently are not changed in the least and the liquid in contact with them is as clear and colorless as when first sealed up. The liquid on the *brass, nickel,* and *silver* has become slightly yellow; that on the *copper* is still good, but the copper has a somewhat roughened appearance as if it had been slightly acted upon.

While *pure zinc* noted above is apparently quite resistant to the action of prussic acid, a piece of plumbers' ordinary *sheet zinc* was soon covered with a white coating and a considerable quantity of white sediment was deposited in the liquid. The liquid itself remained colorless and apparently unaffected throughout the experiment.

*Delivery Drums.*—Judging from the experiments described above and from a consideration of the cost and properties of the various materials observed, aluminum is the most promising material for the construction of delivery drums. Brass fittings appear to be permissible.

## SUMMARY

The ready acceptance, by fumigators, of liquid hydrocyanic acid as a new convenience in citrus fumigation has resulted in a study of the physical and chemical properties of the liquid.

Two test runs of the liquefying plant were made in order to establish a basis of settlement between plant and fumigator. The liquid hydrocyanic acid recovered in the first test run was 80.1 per cent of the greatest possible yield; in the second, 76.3 per cent; an average of 78.2 per cent.

The average purity of the liquid obtained in the first run was 97.57 per cent; in the second, 94.27 per cent.

The average purity of the liquid delivered during the past fumigating season was above 95 per cent absolute hydrocyanic acid. Material of 95 per cent or greater purity is considered of a satisfactory grade.

As the plant was operated last season, the following is believed to be a fair return per case of two hundred pounds of sodium cyanide:

1. A minimum of 85 pounds of absolute hydrocyanic acid; or
2. A minimum of 90 pounds of liquid testing not less than 95 per cent purity.

As the necessary information is accumulated it is confidently anticipated that the yield in the future will be equal to or even greater than that now obtained from the portable generators in common use.

The weight basis for commercial transactions is strongly urged for adoption in preference to the volume basis now in use. Deliveries could be more easily checked up by weighing than by measuring, and this is also less dangerous. Furthermore, the weight of the recovered liquid will be the same at any temperature, while the corresponding number of gallons will vary according to the temperature at which it is measured.

A table has been prepared showing the weights and corresponding volumes of various grades of commercial liquid and the quantities thereof corresponding to various percentages of the maximum yield (Table I).

It has been determined that the acid is miscible with water in all proportions and will not stratify upon standing.

Hydrocyanic acid evaporates more rapidly than water from dilute mixtures of the two.

Complete data have been obtained on the specific gravity of commercial liquid hydrocyanic acid testing from 70 per cent to 100 per

cent purity, and upon the extent of variation of hydrometer readings as affected by temperature. These figures are presented in the form of reference tables at the end of the bulletin. These tables make it possible to determine the quality of a liquid in a moment's time by the use of a hydrometer graduated either in specific gravity or Baumé degrees.

The accumulation of the data referred to above has made possible the construction of a cyanometer, a hydrometer graduated directly in percentages of hydrocyanic acid and provided with a simple table of temperature corrections.

A method of analysis has been selected and shown to give concordant results within two-tenths of 1 per cent.

The development of any color, usually yellow, or an odor of ammonia may be taken as a warning of incipient decomposition of the liquid.

Factors and materials favoring decomposition are: water in excess of 5 per cent; high temperatures; residue from a decomposed liquid; all alkalies, nitric acid, sodium cyanide; soap; or contact with lead, commercial tin, impure zinc, solder, cast iron, or steel.

The following metals were found to be highly resistant to the acid, somewhat in the order named: aluminum, block tin, pure zinc, brass, nickel, silver, and copper.

Aluminum is the most promising material for the construction of delivery drums. Brass fittings are permissible.

## REFERENCE TABLES

The following reference tables and their use in determining the percentage of absolute hydrocyanic acid in commercial liquid hydrocyanic acid have been discussed under the heading "Specific Gravity" in the section on physical properties.

## TABLE VI

### For Use With Specific Gravity Hydrometer

Calibrated at 15° C

| Observed Specific Gravity | Observed Temperature ° C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 |
| | Corresponding Percent. Hydrocyanic Acid | | | | | | | | |
| .690 | 99.7 | ..... | ..... | ..... | ..... | ..... | ..... | | |
| .692 | 99.1 | 99.5 | 99.9 | ..... | ..... | ..... | ..... | | |
| .694 | 98.5 | 98.9 | 99.3 | 99.7 | ..... | ..... | ..... | ..... | |
| .696 | 97.9 | 98.3 | 98.7 | 99.1 | 99.5 | 99.9 | ..... | ..... | |
| .698 | 97.3 | 97.7 | 98.1 | 98.5 | 98.9 | 99.3 | 99.7 | 100 | ..... |
| .700 | 96.7 | 97.1 | 97.5 | 97.9 | 98.3 | 98.7 | 99.1 | 99.6 | 100 |
| .702 | 96.1 | 96.5 | 96.9 | 97.3 | 97.7 | 98.1 | 98.5 | 98.9 | 99.4 |
| .704 | 95.5 | 95.9 | 96.3 | 96.7 | 97.1 | 97.5 | 97.9 | 98.4 | 98.8 |
| .706 | 94.9 | 95.3 | 95.7 | 96.1 | 96.5 | 96.9 | 97.3 | 97.8 | 98.2 |
| .708 | 94.3 | 94.7 | 95.1 | 95.5 | 95.9 | 96.3 | 96.7 | 97.1 | 97.6 |
| .710 | 93.7 | 94.1 | 94.5 | 94.9 | 95.3 | 95.7 | 96.1 | 96.5 | 97.0 |
| .712 | 93.1 | 93.5 | 93.9 | 94.3 | 94.7 | 95.1 | 95.5 | 95.9 | 96.4 |
| .714 | 92.6 | 93.0 | 93.4 | 93.8 | 94.2 | 94.6 | 95.0 | 95.3 | 95.8 |
| .716 | 92.0 | 92.4 | 92.8 | 93.2 | 93.6 | 94.0 | 94.4 | 94.7 | 95.2 |
| .718 | 91.4 | 91.8 | 92.2 | 92.6 | 93.0 | 93.4 | 93.8 | 94.1 | 94.6 |
| .720 | 90.8 | 91.2 | 91.6 | 92.0 | 92.4 | 92.8 | 93.2 | 93.6 | 94.0 |
| .722 | 90.2 | 90.6 | 91.0 | 91.4 | 91.8 | 92.2 | 92.6 | 93.0 | 93 4 |
| .724 | 89.6 | 90.0 | 90.4 | 90.8 | 91.2 | 91.6 | 92.0 | 92.4 | 92.8 |
| .726 | 89.0 | 89.4 | 89.8 | 90.2 | 90.6 | 91.0 | 91.4 | 91.8 | 92.2 |
| .728 | 88.5 | 88.9 | 89.3 | 89.7 | 90.1 | 90.5 | 90.9 | 91.2 | 91.6 |
| .730 | 87.9 | 88.3 | 88.7 | 89.1 | 89.5 | 89.9 | 90.3 | 90.6 | 91.0 |
| .732 | 87.3 | 87.7 | 88 1 | 88.5 | 88.9 | 89.3 | 89.7 | 90.0 | 90 4 |
| .734 | 86.7 | 87.1 | 87.5 | 87.9 | 88.3 | 88.7 | 89.1 | 89.4 | 89.8 |
| .736 | 86.2 | 86.5 | 87.0 | 87.4 | 87.8 | 88.2 | 88.6 | 88.8 | 89 2 |
| .738 | 85.6 | 86.0 | 86.4 | 86.8 | 87.2 | 87.5 | 87.9 | 88.2 | 88.6 |
| .740 | 85.0 | 85.4 | 85.8 | 86.2 | 86.6 | 86.9 | 87.3 | 87.6 | 88.0 |
| .742 | 84.4 | 84.8 | 85.2 | 85.6 | 86.0 | 86.3 | 86.7 | 87.0 | 87.4 |
| .744 | 83.8 | 84.2 | 84.6 | 85.0 | 85.4 | 85.7 | 86.1 | 86.4 | 86.8 |
| .746 | 83.3 | 83.7 | 84.1 | 84.5 | 84.8 | 85.1 | 85.5 | 85.8 | 86.2 |
| .748 | 82.7 | 83.1 | 83.5 | 83.9 | 84.2 | 84.5 | 84.9 | 85 2 | 85.6 |
| .750 | 82.1 | 82.5 | 82.9 | 83.3 | 83.6 | 83.9 | 84.3 | 84 6 | 85.0 |
| .752 | 81.6 | 82.0 | 82.4 | 82.7 | 83.0 | 83.3 | 83.6 | 84 0 | 84.4 |
| .754 | 81.0 | 81.4 | 81.8 | 82.1 | 82 4 | 82.7 | 83.1 | 83 5 | 83.8 |
| 756 | 80.4 | 80.8 | 81.2 | 81.5 | 81.8 | 82.1 | 82.5 | 82 9 | 83.2 |

TABLE VI (*Continued*)

For Use With Specific Gravity Hydrometer

Calibrated at 15° C

| Observed Specific Gravity | Observed Temperature ° C | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 |
| | Corresponding Percent. Hydrocyanic Acid | | | | | | | | |
| .690 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| .692 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| .694 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| .696 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| .698 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| .700 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| .702 | 99.8 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| .704 | 99.2 | 99.6 | 100 | ..... | ..... | ..... | ..... | ..... | ..... |
| .706 | 98.6 | 99.0 | 99.4 | 99.8 | ..... | ..... | ..... | ..... | ..... |
| .708 | 98.0 | 98.4 | 98.8 | 99.2 | 99.6 | 100 | ..... | ..... | ..... |
| .710 | 97.4 | 97.8 | 98.2 | 98.6 | 99.0 | 99.4 | 99.9 | ..... | ..... |
| .712 | 96.8 | 97.2 | 97.6 | 98.0 | 98.4 | 98.8 | 99.3 | 99.7 | ..... |
| .714 | 96.2 | 96.6 | 97.0 | 97.4 | 97.8 | 98.2 | 98.7 | 99.1 | 99.6 |
| .716 | 95.6 | 96.0 | 96.4 | 96.7 | 97.2 | 97.6 | 98.1 | 98.5 | 99.0 |
| .718 | 95.0 | 95.4 | 95.8 | 96.1 | 96.6 | 97.0 | 97.5 | 97.9 | 98.4 |
| .720 | 94.4 | 94.8 | 95.2 | 95.5 | 96.0 | 96.4 | 96.9 | 97.3 | 97.8 |
| .722 | 93.8 | 94.2 | 94.5 | 94.9 | 95.3 | 95.8 | 96.2 | 96.6 | 97.1 |
| .724 | 93.2 | 93.6 | 93.9 | 94.3 | 94.7 | 95.1 | 95.6 | 96.0 | 96.5 |
| .726 | 92.6 | 93.0 | 93.3 | 93.7 | 94.1 | 94.5 | 95.0 | 95.4 | 95.9 |
| .728 | 92.0 | 92.4 | 92.8 | 93.1 | 93.5 | 93.9 | 94.3 | 94.7 | 95.3 |
| .730 | 91.4 | 91.8 | 92.2 | 92.5 | 92.9 | 93.3 | 93.7 | 94.1 | 94.7 |
| .732 | 90.8 | 91.2 | 91.6 | 91.9 | 92.3 | 92.7 | 93.1 | 93.5 | 94.0 |
| .734 | 90.2 | 90.6 | 91.0 | 91.3 | 91.7 | 92.1 | 92.5 | 92.9 | 93.4 |
| .736 | 89.6 | 90.0 | 90.4 | 90.7 | 91.1 | 91.5 | 91.9 | 92.3 | 92.8 |
| .738 | 89.0 | 89.4 | 89.8 | 90.1 | 90.5 | 90.9 | 91.3 | 91.7 | 92.2 |
| .740 | 88.4 | 88.8 | 89.2 | 89.5 | 89.9 | 90.3 | 90.7 | 91.1 | 91.6 |
| .742 | 87.8 | 88.2 | 88.6 | 88.9 | 89.3 | 89.7 | 90.1 | 90.5 | 91.0 |
| .744 | 87.2 | 87.6 | 88.0 | 88.3 | 88.7 | 89.1 | 89.5 | 89.9 | 90.4 |
| .746 | 86.6 | 87.0 | 87.4 | 87.7 | 88.1 | 88.5 | 88.9 | 89.3 | 89.8 |
| .748 | 86.0 | 86.4 | 86.8 | 87.1 | 87.5 | 87.9 | 88.3 | 88.7 | 89.1 |
| .750 | 85.4 | 85.8 | 86.2 | 86.5 | 86.9 | 87.3 | 87.7 | 88.1 | 88.5 |
| .752 | 84.8 | 85.2 | 85.6 | 85.9 | 86.3 | 86.7 | 87.1 | 87.5 | 87.9 |
| .754 | 84.2 | 84.6 | 85.0 | 85.3 | 85.7 | 86.1 | 86.5 | 86.9 | 87.3 |
| .756 | 83.6 | 84.0 | 84.4 | 84.7 | 85.1 | 85.5 | 85.9 | 86.3 | 86.7 |

## TABLE VII

### For Use With Baume Hydrometer

Calibrated at 60°F.

| Observed Degrees Baume. | Observed Temperature °F. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 70 | 69 | 68 | 67 | 66 | 65 | 64 | 63 | 62 | 61 | 60 |
| | Corresponding Percent. Hydrocyanic Acid | | | | | | | | | | |
| 72.5 | 99.7 | 100 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 72.0 | 99.1 | 99.3 | 99.5 | 99.7 | 99.9 | ..... | ..... | ..... | ..... | ..... | ..... |
| 71.5 | 98.6 | 98.8 | 99.0 | 99.2 | 99.4 | 99.7 | 100 | ..... | ..... | ..... | ..... |
| 71.0 | 98.1 | 98.3 | 98.6 | 98.8 | 99.0 | 99.2 | 99.4 | 99.6 | 99.8 | 100 | ..... |
| 70.5 | 97.6 | 97.8 | 98.0 | 98.2 | 98.4 | 98.6 | 98.8 | 99.1 | 99.3 | 99.5 | 99.7 |
| 70.0 | 97.1 | 97.3 | 97.5 | 97.7 | 98.0 | 98.2 | 98.4 | 98.7 | 98.9 | 99.1 | 99.3 |
| 69.5 | 96.6 | 96.8 | 97.0 | 97.2 | 97.4 | 97.6 | 97.8 | 98.0 | 98.2 | 98.4 | 98.7 |
| 69.0 | 96.1 | 96.3 | 96.5 | 96.7 | 97.0 | 97.2 | 97.4 | 97.6 | 97.8 | 98.1 | 98.3 |
| 68.5 | 95.5 | 95.7 | 95.9 | 96.1 | 96.4 | 96.6 | 96.9 | 97.1 | 97.3 | 97.6 | 97.8 |
| 68.0 | 95.0 | 95.2 | 95.4 | 95.6 | 95.9 | 96.1 | 96.3 | 96.5 | 96.8 | 97.0 | 97.2 |
| 67.5 | 94.4 | 94.6 | 94.8 | 95.0 | 95.3 | 95.5 | 95.7 | 95.9 | 96.1 | 96.4 | 96.6 |
| 67.0 | 93.9 | 94.1 | 94.3 | 94.5 | 94.8 | 95.0 | 95.2 | 95.4 | 95.6 | 95.9 | 96.1 |
| 66.5 | 93.4 | 93.6 | 93.8 | 94.0 | 94.3 | 94.5 | 94.7 | 94.9 | 95.2 | 95.4 | 95.6 |
| 66.0 | 92.9 | 93.1 | 93.3 | 93.5 | 93.7 | 94.0 | 94.2 | 94.4 | 94.6 | 94.9 | 95.1 |
| 65.5 | 92.4 | 92.6 | 92.8 | 93.0 | 93.2 | 93.5 | 93.7 | 93.9 | 94.1 | 94.3 | 94.5 |
| 65.0 | 91.8 | 92.0 | 92.2 | 92.4 | 92.6 | 92.8 | 93.1 | 93.3 | 93.5 | 93.7 | 93.9 |
| 64.5 | 91.2 | 91.4 | 91.6 | 91.8 | 92.1 | 92.3 | 92.5 | 92.7 | 92.9 | 93.2 | 93.4 |
| 64.0 | 90.7 | 90.9 | 91.1 | 91.3 | 91.6 | 91.8 | 92.0 | 92.2 | 92.4 | 92.7 | 92.9 |
| 63.5 | 90.1 | 90.3 | 90.5 | 90.7 | 90.9 | 91.2 | 91.4 | 91.6 | 91.8 | 92.1 | 92.3 |
| 63.0 | 89.6 | 89.8 | 90.0 | 90.2 | 90.5 | 90.7 | 90.9 | 91.1 | 91.4 | 91.6 | 91.8 |
| 62.5 | 89.1 | 89.3 | 89.5 | 89.7 | 89.9 | 90.2 | 90.4 | 90.6 | 90.8 | 91.0 | 91.2 |
| 62.0 | 88.5 | 88.7 | 88.9 | 89.1 | 89.3 | 89.6 | 89.8 | 90.0 | 90.2 | 90.4 | 90.6 |
| 61.5 | 88.0 | 88.2 | 88.4 | 88.6 | 88.8 | 89.0 | 89.3 | 89.5 | 89.7 | 89.9 | 90.1 |
| 61.0 | 87.3 | 87.5 | 87.7 | 87.9 | 88.1 | 88.3 | 88.6 | 88.8 | 89.0 | 89.2 | 89.4 |
| 60.5 | 86.8 | 87.0 | 87.2 | 87.4 | 87.6 | 87.8 | 88.0 | 88.3 | 88.5 | 88.7 | 88.9 |
| 60.0 | 86.3 | 86.5 | 86.7 | 86.9 | 87.1 | 87.4 | 87.6 | 87.8 | 88.0 | 88.2 | 88.4 |
| 59.5 | 85.8 | 86.0 | 86.2 | 86.4 | 86.6 | 86.8 | 87.0 | 87.2 | 87.4 | 87.6 | 87.8 |
| 59.0 | 85.2 | 85.4 | 85.6 | 85.8 | 86.0 | 86.2 | 86.4 | 86.6 | 86.8 | 87.0 | 87.2 |
| 58.5 | 84.6 | 84.8 | 85.0 | 85.2 | 85.4 | 85.6 | 85.8 | 86.0 | 86.2 | 86.4 | 86.6 |
| 58.0 | 84.0 | 84.2 | 84.4 | 84.6 | 84.8 | 85.0 | 85.2 | 85.4 | 85.6 | 85.8 | 86.0 |
| 57.5 | 83.5 | 83.7 | 83.9 | 84.1 | 84.3 | 84.5 | 84.7 | 84.9 | 85.1 | 85.3 | 85.5 |
| 57.0 | 82.9 | 83.1 | 83.3 | 83.5 | 83.7 | 83.9 | 84.1 | 84.3 | 84.5 | 84.7 | 84.9 |
| 56.5 | 82.3 | 82.5 | 82.7 | 82.9 | 83.1 | 83.3 | 83.5 | 83.7 | 83.9 | 84.1 | 84.3 |

TABLE VII (*Continued*)

FOR USE WITH BAUME HYDROMETER

Calibrated at 60°F.

| Observed Degrees Baume | Observed Temperature °F. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 59 | 58 | 57 | 56 | 55 | 54 | 53 | 52 | 51 | 50 |
| | Corresponding Percent. Hydrocyanic Acid | | | | | | | | | |
| 72.5 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 72.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 71.5 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 71.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 70.5 | 100 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 70.0 | 99.6 | 99.8 | 100 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 69.5 | 99.0 | 99.2 | 99.4 | 99.6 | 99.8 | 100 | ..... | ..... | ..... | ..... |
| 69.0 | 98.5 | 98.7 | 98.9 | 99.1 | 99.3 | 99.5 | 99.8 | 100 | ..... | ..... |
| 68.5 | 98.0 | 98.2 | 98.4 | 98.6 | 98.8 | 99.0 | 99.3 | 99.5 | 99.7 | 100 |
| 68.0 | 97.4 | 97.6 | 97.8 | 98.1 | 98.3 | 98.5 | 98.8 | 99.0 | 99.2 | 99.5 |
| 67.5 | 96.9 | 97.1 | 97.3 | 97.5 | 97.8 | 98.0 | 98.2 | 98.4 | 98.6 | 98.9 |
| 67.0 | 96.3 | 96.5 | 96.8 | 97.0 | 97.2 | 97.5 | 97.7 | 97.9 | 98.1 | 98.4 |
| 66.5 | 95.8 | 96.0 | 96.3 | 96.5 | 96.7 | 96.9 | 97.1 | 97.4 | 97.6 | 97.8 |
| 66.0 | 95.3 | 95.5 | 95.7 | 96.0 | 96.2 | 96.4 | 96.6 | 96.9 | 97.1 | 97.3 |
| 65.5 | 94.7 | 95.0 | 95.2 | 95.4 | 95.6 | 95.9 | 96.1 | 96.3 | 96.5 | 96.7 |
| 65.0 | 94.1 | 94.4 | 94.6 | 94.8 | 95.0 | 95.3 | 95.5 | 95.7 | 95.9 | 96.1 |
| 64.5 | 93.6 | 93.8 | 94.0 | 94.3 | 94.5 | 94.7 | 94.9 | 95.1 | 95.3 | 95.5 |
| 64.0 | 93.1 | 93.3 | 93.5 | 93.7 | 94.0 | 94.2 | 94.4 | 94.6 | 94.8 | 95.0 |
| 63.5 | 92.5 | 92.7 | 92.9 | 93.1 | 93.4 | 93.6 | 93.8 | 94.0 | 94.2 | 94.4 |
| 63.0 | 92.0 | 92.2 | 92.4 | 92.6 | 92.9 | 93.1 | 93.3 | 93.5 | 93.7 | 93.9 |
| 62.5 | 91.4 | 91.7 | 91.9 | 92.1 | 92.3 | 92.5 | 92.7 | 92.9 | 93.1 | 93.3 |
| 62.0 | 90.8 | 91.0 | 91.3 | 91.5 | 91.7 | 91.9 | 92.1 | 92.3 | 92.5 | 92.7 |
| 61.5 | 90.3 | 90.5 | 90.7 | 90.9 | 91.1 | 91.3 | 91.5 | 91.8 | 92.0 | 92.2 |
| 61.0 | 89.6 | 89.8 | 90.0 | 90.4 | 90.5 | 90.7 | 90.9 | 91.2 | 91.4 | 91.6 |
| 60.5 | 89.1 | 89.3 | 89.5 | 89.8 | 90.0 | 90.2 | 90.4 | 90.6 | 90.8 | 91.0 |
| 60.0 | 88.6 | 88.8 | 89.0 | 89.3 | 89.5 | 89.7 | 89.9 | 90.1 | 90.3 | 90.5 |
| 59.5 | 88.0 | 88.3 | 88.5 | 88.7 | 88.9 | 89.1 | 89.3 | 89.5 | 89.7 | 89.9 |
| 59.0 | 87.4 | 87.6 | 87.9 | 88.1 | 88.3 | 88.5 | 88.7 | 88.9 | 89.1 | 89.3 |
| 58.5 | 86.8 | 87.0 | 87.3 | 87.5 | 87.7 | 87.9 | 88.1 | 88.3 | 88.5 | 88.7 |
| 58.0 | 86.2 | 86.5 | 86.7 | 86.9 | 87.1 | 87.3 | 87.5 | 87.7 | 87.9 | 88.1 |
| 57.5 | 85.7 | 85.9 | 86.1 | 86.3 | 86.5 | 86.7 | 86.9 | 87.1 | 87.3 | 87.5 |
| 57.0 | 85.1 | 85.3 | 85.5 | 85.7 | 85.9 | 86.1 | 86.3 | 86.5 | 86.7 | 86.9 |
| 56.5 | 84.5 | 84.7 | 84.9 | 85.1 | 85.3 | 85.5 | 85.7 | 85.9 | 86.1 | 86.3 |

TABLE VII (*Concluded*)

FOR USE WITH BAUME HYDROMETER

Calibrated at 60°F.

| Observed Degrees Baume | Observed Temperature °F. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 |
| | Corresponding Percent. Hydrocyanic Acid | | | | | | | | | |
| 72.5 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 72.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 71.5 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 71.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 70.5 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 70.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 69.5 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 69.0 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 68.5 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 68.0 | 99.7 | 10 ) | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| 67.5 | 99.1 | 99.4 | 99.6 | 99.9 | ..... | ..... | ..... | ..... | ..... | ..... |
| 67.0 | 98.6 | 98.8 | 99.1 | 99.3 | 99.6 | 99.8 | 100 | ..... | ..... | ..... |
| 66.5 | 98.0 | 98.3 | 98.5 | 98.7 | 99.0 | 99.2 | 99.4 | 99.6 | 99.8 | 100 |
| 66.0 | 97.5 | 97.8 | 98.0 | 98.3 | 98.5 | 98.7 | 98.9 | 99.1 | 99.3 | 99.5 |
| 65.5 | 97.0 | 97.2 | 97.5 | 97.7 | 98.0 | 98.2 | 98.4 | 98.6 | 98.9 | 99.1 |
| 65.0 | 96.4 | 96.6 | 96.9 | 97.2 | 97.4 | 97.7 | 97.9 | 98.1 | 98.4 | 98.6 |
| 64.5 | 95.8 | 96.0 | 96.3 | 96.6 | 96.8 | 97.1 | 97.3 | 97.6 | 97.8 | 98.1 |
| 64.0 | 95.3 | 95.5 | 95.8 | 96.0 | 96.3 | 96.5 | 96.8 | 97.0 | 97.2 | 97.5 |
| 63.5 | 94.7 | 94.9 | 95.2 | 95.5 | 95.7 | 95.9 | 96.2 | 96.4 | 96.6 | 96.9 |
| 63.0 | 94.2 | 94.4 | 94.7 | 94.9 | 95.1 | 95.4 | 95.6 | 95.9 | 96.1 | 96.3 |
| 62.5 | 93.6 | 93.8 | 94.1 | 94.3 | 94.6 | 94.8 | 95.1 | 95.3 | 95.5 | 95.7 |
| 62.0 | 93.0 | 93.2 | 93.5 | 93.7 | 94.0 | 94.2 | 94.5 | 94.7 | 94.9 | 95.1 |
| 61.5 | 92.4 | 92.7 | 92.9 | 93.2 | 93.4 | 93.6 | 93.9 | 94.1 | 94.4 | 94.6 |
| 61.0 | 91.8 | 92.1 | 92.3 | 92.6 | 92.8 | 93.0 | 93.3 | 93.5 | 93.7 | 93.9 |
| 60.5 | 91.3 | 91.5 | 91.7 | 92.0 | 92.2 | 92.4 | 92.7 | 92.9 | 93.1 | 93.3 |
| 60.0 | 90.8 | 91.0 | 91.2 | 91.5 | 91.7 | 91.9 | 92.1 | 92.4 | 92.6 | 92.8 |
| 59.5 | 90.2 | 90.4 | 90.6 | 90.9 | 91.1 | 91.3 | 91.5 | 91.8 | 92.0 | 92.2 |
| 59.0 | 89.6 | 89.8 | 90.0 | 90.3 | 90.5 | 90.7 | 90.9 | 91.2 | 91.4 | 91.6 |
| 58.5 | 89.0 | 89.2 | 89.4 | 89.7 | 89.9 | 90.1 | 90.3 | 90.6 | 90.8 | 91.0 |
| 58.0 | 88.4 | 88.6 | 88.8 | 89.1 | 89.3 | 89.5 | 89.7 | 90.0 | 90.2 | 90.4 |
| 57.5 | 87.8 | 88.0 | 88.2 | 88.4 | 88.7 | 88.9 | 89.1 | 89.4 | 89.6 | 89.8 |
| 57.0 | 87.2 | 87.4 | 87.6 | 87.8 | 88.0 | 88.3 | 88.5 | 88.7 | 88.9 | 89.1 |
| 56.5 | 86.6 | 86.8 | 87.0 | 87.2 | 87.4 | 87.6 | 87.8 | 88.0 | 88.2 | 88.4 |

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